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MEASURING THE STRATEGIC BALANCE. WORKING PAPERS FOR THE INTERNA--ETC(U)
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MEASURING THE STRATEGIC BALANCE

WORKING PAPERS FOR THE INTERNATIONAL INSTITUTE OF STRATEGIC STUDIES

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Presents a range of different approaches to measuring the strategic balance ranging from static analysis to war gaming. The handbook was developed by various experts within the Department of Defense and the U.S. national security community as an aid to members of the military studies community who do not have access to classified information. The handbook covers such subjects as: → next page

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cont.

#20. -- summary presentation of the balance.
-- unclassified analytic tools and reference data for measuring the balance.
-- relative merit of different measurement techniques.
-- means of projecting the balance into the 1980s.
-- new factors and technology shaping the future balance.

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INTRODUCTION TO WORKING PAPERS ON
MEASURING THE STRATEGIC BALANCE

The measurement of the strategic balance was comparatively simple during the period in which the United States had a commanding lead in strategic forces. The choice of data and measurement techniques could alter the degree of superiority, but not the overall nature of the balance. Further, the implications of the balance for war fighting were also comparatively simple. The Soviet Union lacked the force strength and accuracy to seriously challenge the survival of U.S. strategic forces or any pole of the U.S. triad. Changes in the particular method of analysis used in modeling a possible conflict could introduce variations in the outcome of an exchange model, but not alter the overall result.

The problem of measuring the strategic balance has grown steadily more complex, however, as Soviet forces have approached U.S. forces in strength and capability. The choice of given parameters and data can now produce very different pictures of who is ahead, and of the outcome of possible conflicts. Relatively minor changes in the estimate of force trends can skew the long term balance even more sharply.

This trend towards parity has been accompanied by other complicating factors:

-- steady improvements in accuracy technology which make yield, hardness, fraticide, and other complex technical measures steadily more important in determining overall systems capability.

-- the discussion of the use of strategic forces in limited nuclear options involving complex conflict scenarios. Many of these scenarios give forces different strengths and weaknesses from those which characterize the same forces in an all-out strategic exchange.

-- improvements in warhead and accuracy numbers which make it possible to conduct credible counterforce strikes against at least a part of the triad on each side.

-- the growing "blurring" of the difference between strategic and tactical systems as strategic systems acquire almost universal theater strike capability, and "tactical" systems acquire strategic capability and range.

-- development of counter-value strike strategies which are more complex than the models of the early 1950s, and which lead to very different attack models and options than simple counter-population or industrial complex targeting.

-- a continuing arms control effort which influences the resource decisions and force plans of both sides accordingly to different criteria from those which would shape purely military goals and objectives.

-- steadily current and potential capabilities to defend against given elements of the triad using techniques such as advanced ASW, low altitude air defense, anti-missile systems, and electronic warfare.

-- the problem of tying perceptions of the balance to differ actual force capabilities. Near parity in some areas of strategic forces often leads to public and political perception of the balance which differs sharply from the perception of military planners and technical experts.

-- the growth of "national" strategic forces in France and China.

-- the development of potentially mobile ICBMs, and the development of long range cruise missiles technology.

-- the continuing increase in the sophistication of command and control, warning, intelligence, and damage assessment systems. These systems can significantly alter the capability of each side to fight given types of war.

There are many other factors which can be added to this list, but all would illustrate the need for the strategic studies community to improve its analysis and measurement of the strategic balance.

In fact, a review of the current literature on the balance illustrates how many different conclusions can be drawn from virtually the same data when only part of the factors shaping the balance are analyzed and models do not evolve to match the complexity of the situation under study. Such review also shows how easy it is to draw firm conclusions by ignoring real world uncertainties, or by shaping the trend analysis along a given line rather than a spread of possible futures.

The papers in this volume are designed to assist the strategic studies community in adopting more sophisticated measures of the balance, in coping with the growing complexity of strategic forces, and in measuring the implications of uncertainty. They represent the personal views of the authors, and it must be stressed that they are not the official views of any of the authors' firsm or organizations. They do, however, represent the work of a wide range of experts in the field, and show that major improvements can be made in past reporting.

Inevitably, such papers do not resolve the issues in the balance or lead the reader to choose one method of measuring what the balance is. If anything, they illustrate that there is no single set of valid measures, and that the student of strategic studies must explore a wide range of static and dynamic techniques to understand both present capabilities and future uncertainties.

Anthony H. Cordesman

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THE IMPACT OF SSBNs ON

THE STRATEGIC BALANCE

by

John P. Coyle

ABSTRACT

This is a working paper intended as background for discussions at the I.I.S.S. Workshop on Improving Measures of the Strategic Balance.

While the measurement of SSBN/SLBM contribution is the purpose of this paper, it is only in the context of the strategic balance as a whole that measures appropriate to any component, including SSBN, can be determined. The assessment of measures of the overall balance thus occupies the bulk of this paper. A general review emphasizes problems in measuring overall balance and summarizes the appraisal of SSBN impact. This is followed by a series of technical appendices. These define and illustrate each quantitative measure, and review the history of its use. Suitability in appraisal of the overall balance and the SSBN contribution is noted.

The salient conclusions of the paper are:

- Number of weapons and equivalent megatons in selected force components are the most sensitive measures of offensive force balance.

- The important question whether one side will dominate the balance through successful damage limitation hinges much more on a complex of defensive deployments and capabilities than on relative offensive force levels or counterforce potential.

- Relative advantage (absent damage limitation) hinges on coercive capability while avoiding all-out retaliation. This calls for:

    -- Low counterforce vulnerability to avoid escalatory incentive. (Weapons and EMT targetable by nuclear attack are appropriate measures of vulnerability.)

    -- Enduring survival of an adequate withheld deterrent and flexible response. (Weapons, EMT, hard target capability and flexibility of non-targetable elements of the force are appropriate measures.)

    -- Reasonable assurance that assumed non-targetability will continue. (Diversity of force mix is an appropriate measure.)

- SSBN together with other diverse mobile and recallable components contribute significantly to the favorable measures in the balance thus measured.

The paper relies heavily on memory, off the cuff examples and interpretations. Errors and misconceptions are the author's own and emphatically do not reflect official policy of any organization.

OUTLINE

Page

I. SSBN as an Element in the Military Balance

This paper will discuss measures pertinent to evaluating the impact of sea-based forces on the strategic balance. The views are those of an analyst at the working level within the Navy Department and do not reflect official positions.

The SSB(N) contribution to each of the measures appropriate to the overall force balance will differ from that of other components of the force mix which it complements. There exist very significant differences, moreover, distinguishing the niche occupied by SSBN within each of the Soviet, U.S. and allied strategic forces with their different strategies and opposing threats. Thus, their impact can be measured only within the perspective of the balance as a whole and specifics of the opposing postures. Tab **A** to Appendix B illustrates the conventional contrasting of U.S. vs USSR SSBN. The following paragraphs illustrate some of the aspects that inhibit meaningful assessment in the absence of an overall perspective.

U.S. SLBM are heavily MIRVed to ensure penetration against Soviet defenses; the U.S. targets defended under the ABM treaty are neither as significant nor are they appropriate for Soviet SLBM targeting; UK and French SLBM capabilities are magnified by the leverage their existence imparts within allied command relationships. Soviet SLBM are a counterforce threat enforcing high U.S. bomber alert readiness. To comprise a short time-of-flight counterforce threat to the Soviets, equivalent to an inaccurate Soviet SLBM, U.S. SLBM would have to incorporate hard target capability and threaten silos.

In relation to the total strategic force mix on either side, the contribution of each system is also complementary or synergistic. Such interdependencies cannot be expressed in terms of a fractional share of any particular quantity.

As an offensive force, SSBN contribute characteristic capabilities. They offer the capability for short flight times from unpredictable directions. They enjoy relative freedom from the necessity for commitment once hostilities start (to avoid base loss or exhaustion due to limited endurance). They need not attack in heavy concentrations of force to saturate the defense (given relatively low ABM threats).

Unlike ICBM, but like other mobile systems or alert recallable systems (bombers), SSBN forces of the two sides do not threaten each other. Vulnerability of at-sea SSBNs is to ASW measures. These, generally, do not involve nuclear forces nor massive rapid

pre-emption, but slow attrition. The overall balance is affected by vulnerability to these ASW capabilities but in a different way than by vulnerability to nuclear pre-emption. Like bombers, day-to-day SSBN posture includes a substantial but known fraction of the force in a non-alert status which is vulnerable to nuclear attack. Unlike ICBM, attack of these non-alert systems can be done with very few weapons, but would have to be done without giving the few hours of warning required to permit bombers and SLBM to reach a full alert posture. This constrains the attacker's plan to bring his own total forces to full readiness.

II. Measurement Itself as an Element in the Strategic Balance

The choice of a measure for emphasis can also itself be almost as much an element in the strategic balance as are the hard military facts which the measure summarizes. This is the case especially in a nuclear confrontation, where the urgency of avoiding the ultimate trial by combat is greatest. How the nuclear balance is measured will in large part determine the coercive political impact of perceived superiority. Accepted measures motivate the urgency and types of new nuclear capabilities procured to "restore" the balance.

National and service interests also emphasize measures that portray to best advantage their own position or policies. For these reasons, and because circumstances change, widely accepted measures may not indefinitely reflect either sound strategic evaluation or even later (changing) interests of those who originally stressed them.

The emphasis given in U.S. public debate is on measures that have been interpreted to imply Soviet counterforce threat to MINUTEMAN (throwweight, MIRV and the Modern Large ICBM (MLBM)); similarly the Soviets stress forward based nuclear systems (FBS: NATO support, carriers and SLBM bases). This current stress by each side on the strengths of the other serves a negotiating objective. It facilitates a claim that unilateral advantage warrants compensation in negotiations or justifies a linkage. For example, U.S. stress on ABM silo defense was useful to tie the ABM issue directly to that of limiting offensive strength. This emphasis, made by both sides, far transcends legitimate strategic relevance. FBS capabilities are dwarfed by the overall strategic offensive force, and MINUTEMAN is only one component of U.S. force. Depending on the choice of measures, the MINUTEMAN force can be assessed to have either more or less capability than U.S. SLBM force and/or the Soviet ICBM force. Further, total U.S. missile force can be assessed as more or less capable than U.S. bombers. (See Annex A to Appendix B.)

A responsible and objective evaluation must recognize these distortions, and the degree of their acceptance, as elements in current perceptions of balance. Its own analysis, however, should do more than clerical service measuring the parameters of these arbitrary models. More objective assessments of the overall balance are feasible and should be implemented.

III. Strategic Balance Perceived as a Prospectus of Military Outcomes: Damage Limiting and Counterforce

Classical perceptions of military balance assessed the ability of one side to impose its will on the other through force. They compared two forces each designed to do battle with the other. Forces were characterized by size and unit firepower, and in a battle, each applied firepower to reduce the size of the other. F. W. Lanchester, during WW I illustrated the dynamics of encounter with his well known law assuring victory to the side having the largest value of the product of unit firepower times the square of the number of units. Victory in war resulted from maneuver to force the enemy into combat, when superior forces have been brought to bear, and successful avoidance of combat, when disadvantaged. Given time and generalship to avoid being maneuvered into local disadvantage, the superior force could destroy the enemy forces, and have its territory and population at its mercy. Considerable consensus existed between opponents as to likely outcomes. Either in peacetime, or once the high risk options of movement, surprise and capacity for reinforcement have been tested in war, it was reasonable to expect the inferior force to concede the outcome without insisting on a play to the end. The balance of force was a legitimate indicator of coercive political power because it objectively reflected a demonstrable military potential.

Strategic nuclear confrontation differs from this classical case in one major respect. Only a part of the strategic force on each side is capable of force-on-force engagement. Even here there are qualifications on how far numerical balances can be credited with pre-determining outcomes. Firepower dominates numbers on such a scale that Lanchester's continuous exchange never occurs. Opposing strategic forces may plausibly be so deployed that the "weaker" side could destroy the superior force by striking first. The remaining non-targetable forces on each side which are exempted from this force-on-force confrontation are sizeable. It is possible for them to be decisive, at least in the one-sided sense, that they can deny victory to the attacker. They might step into the force-on-force exchange to deny the enemy the advantage of a survivable residual after destroying the threatening counterforce capability. They can retain a decisive capability for devastating the enemy's civilian and non-strategic military economies.

IV. Measures of the Balance

These complications do not, however, rule out the possibility of defining measures of strategic balance in a way that retains the classical inference of prospective relative power and influence in the event of hostilities. They do suggest a cautious approach toward accepting static numerical ratios as measures of relative advantage.

Some important qualifications are judgmental or contingent and a particular quantitative measure may weigh differently on either side of the balance. An appropriate assessment would highlight ambiguities where they exist rather than cover them up.

Appendix A surveys the quantitative measures that describe the force-on-force exchange and notes how these measures relate to relative advantage in eventual outcomes. It concludes that mutual destruction overwhelms advantage and therefore that comparative advantage presumes that the level of destruction will be limited. This can be done either by a successfully implemented damage limiting strategy or by controlling escalation by coercive threats. Counterforce capability to preempt opposing nuclear threats is an important element in assessing both of these possibilities. The measure of counterforce capability is the military value of the forces that could be destroyed in an attack.

However, a dichotomy arises from the two alternative possibilities which gives measures (including counterforce measures) different weights. On the one hand, damage limiting places great demands on various non-nuclear offensive and defensive measures including ABM (which is constrained by treaty) in addition to preemptive disarming attack. Control of escalation requires both restraint and a posture which invites restraint rather than preemption.

For damage limitation, counterforce attack capability is probably necessary but certainly not sufficient. Enough destructive force on both sides is in non-targetable modes to make this so. The determining indicators of a damage limiting posture are a broad complex of other developments which are not measureable by counting strategic forces. Successful deployment of a full damage limiting capability by one side would totally dominate any relative advantage consideration if the capability relied largely on defenses rather than a preemptive first strike. If damage limitation requires a preemptive first strike, and especially if this strike capability is based so that it is itself vulnerable to preemption, serious instability in a crisis would ensue. Crisis stability as noted in Appendix A requires that neither side perceive decisive advantage from initiating all-out attack.

If neither side succeeds in dominating the balance with a full damage limiting capability, other measures of relative balance are important. The relative strengths of the two sides in this case are reflected very largely in the relative availability of options to limit escalation and enforce advantageous termination by other means. To retain control of the situation requires preserving the capability to do at least as much countervalue damage to the other side as would be received. It requires an indomitable force which can retain this capability while avoiding either executing or inviting uncontrolled escalation. Too high a vulnerability to a disarming attack makes escalation beyond the level appropriate to such control attractive to either side. This seriously impairs the credibility of a strategy of restraint.

Appendix B illustrates measures that are useful as indicators of this aspect of the balance. They require separate display of the capability deployed in various modes: targetable by nuclear preemptive attack, conditionally targetable unless given strategic warning, and systems which are not targetable.

SLBM, together with other systems which are outside the force-on-force interaction contribute significantly to this capability for limiting escalation. In assessing this contribution both their counterforce and countervalue contribution to the non-targetable sector should be evaluated.

V. Stability and Uncertainty in the Strategic Balance

The operable measures of the current strategic balance are reasonably well described militarily by the comparative damage limiting/flexible response capabilities described above and by the current "diplomatic sufficiency" interpretations which reflect their coercive potential on the world scene. Crisis stability is a separate characteristic of the balance more or less indifferent to relative advantage. This is because the disadvantaged side may feel the urgency of tipping the balance by preemption. While strategies exist (Herman Kahn's "rationale of irrationality") which involve playing the risk of mutual suicide for tactical advantage; these are available to either side. Other aspects of stability are described in Appendix A.

In addition to these measures of current capability and the trends which facilitate projections of them into the future, it is important to measure the sensitivity of projections to unexpected new developments. The notion that a diverse mix of strategic forces would hedge against these uncertainties has been widely held. The assessment of strategic balance should evaluate adequacy of the hedges inherent in the deployments by the two sides to reduce the risks.

Appendix C discusses measures of assurance against catastrophic failure or obsolescence. The degree of reliance upon a given element in a force mix is a measure both of the commitment to its continued viability and of the incentive offered the other side to develop a decisive countermeasure. The impact on the posture is self-evident where such over-commitment has already induced potentially decisive developments. This is currently the case in respect to hard target counterforce.

What is not so self-evident and needs careful attention is the danger of increased commitment to remaining elements. The evolving postures should be examined critically to assess whether new deployments to offset known vulnerabilities incorporate enough separate types to preserve the hedge against counters that are not currently forecast.

VI. Applicability of SSBN Capability Measures to Their Contribution to the Balance

On both sides SLBM countervalue capability supplements the second strike deterrent and the flexible response contribution of other survivable components. Weapons and EMT are both measures of this capability.

British and French SLBM provide an independent initiative option either to escalate regional hostilities to a nuclear level or to retain a deterrent against coercion in the aftermath of an exchange between the central powers.

SSBN counterforce contribution to the balance must be assessed differently for the two sides.

On the Soviet side, the SLBM anti-bomber capability supplements their ICBM first strike capability since its effectiveness is largely contingent on relaxed U.S. bomber alert readiness.

On both sides, hard target SLBM capability, when and if acquired, supplements flexible response and second strike counter-force capability of the non-targetable part of the posture that offsets the vulnerability of forces engaged in the force-on-force confrontation.

These contributions must all be qualified by estimates of the impact of opposing countermeasures. Especially to be looked for are the following:

° A development leading to a preemptive capability in contrast to the attritive threat of conventional ASW. This would shift SSBN into the force-on-force confrontation and change significantly their influence on the balance.

° Potential heavy ABM deployment, e.g., clandestine or after SALT abrogation. Failing measures to make SSBN targetable, ABM is the remaining damage limiting counter against these weapons.

APPENDIX A

MEASURES OF COUNTERFORCE/DAMAGE LIMITING/FIRST AND SECOND STRIKE CAPABILITIES AND STABILITY

A. Definitions

- A counterforce attack is in contrast to a countervalue attack, which destroys urban industrial (U/I) targets, population and the economic base.

- The counterforce capability of a strategic force is generally viewed as its ability to attack at source and preempt the launch of opposing systems. The measure of counterforce capability is the military potential (EMT/throwweight/weapons/etc.) of the forces it could expect to destroy, for some purposes best expressed as a fraction of the total, for others as an absolute value.

- Other measures for forestalling or mitigating attack are:

  - Attrition by prolonged hostile action, e.g., ASW (measure, how much capability forestalled).

  - Active defense - (ABM/SAM/Interceptors) (measure: capability intercepted)

  - Virtual attrition - enforcing diversion of capability, e.g., for penetration aids, defense suppression, saturation, etc. (measure: capability loss)

  - Successful use of flexible response to limit hostilities short of the countervalue exchange.

- Damage limitation is the successful combination of all these means to reduce consequences of an enemy attack to an "acceptable" level.

- A first strike capability is one which can initiate hostilities and achieve acceptable damage limitation.

- Second strike capability denies the other side a first strike capability by ensuring sufficient survivable force capability to retain the initiative including capability to penetrate and do unacceptable countervalue damage.

- Second strike damage limiting capability would absorb an attack and emerge with military economic and political strengths relatively unimpaired.

° Relative damage limitation measures capabilities short of limiting damage acceptably but which may be perceived as a coercive advantage for limiting escalation.

° There are several types of "stability" considered:

  - One side has secure second strike damage limiting capability - dominates.

  - Mutual deterrence - both sides have second strike capability.

  - Crisis stability - if hostilities threaten, neither side sees enough advantage in going first.

    -- To wish to seize the opportunity to preempt

    -- To assume an accident-prone state of readiness

  - Nuclear arms race stability - The situation as perceived does not encourage increased nuclear force buildup to take advantage of a weakness or rectify one.

° Annexes A-1 - A-5 define specific quantitative measures that apply. Appendix B further elaborates on the impact on the balance.

o Comment

° Counterforce capability requires:

  - Force at risk be targetable (ports, airfields, silos).

  - Weapons be suitable (e.g. accurate against silos).

  - Targets be occupied (scenario).

° Attrition takes time (ASW the air power battle) - War at sea in advance sometimes postulated.

° Active and passive defense are complicated by preferential aspects: attacker can saturate (at cost of virtual attrition); defender may defend preferentially, intercept only weapons aimed at certain targets, secretly deploy defenses to cover others.

° "Acceptable" levels of damage limitation are objectively undefinable. 200-400 EMT on cities has been posed by some as "unacceptable." thus defining a criterion for second strike capability.

- EMT (see Annex A-2) is a useful measure of the capability damage limiting is trying to forestall and of the target value by which counterforce capability for damage limiting is measured. Tab A taken from a 1970 study illustrates trends in the division within the U.S. day-to-day posture between EMT loadings in targetable (ICBM, non-alert bombers and SLBM) and non-targetable forces. The gap between the median dark line and the total force loading is a then current unofficial postulated measure of Soviet counterforce capability. The forces below the median line are the challenge for other Soviet damage limiting measures.

- Stability measures qualify both deterrence (hostilities less likely in a crisis or if one side dominates or if arms races don't escalate, etc.) and the contribution of various other measures to the relative strategic balance (control of escalation implausible if escalation dictated by instabilities).

B. History

- The term "counterforce" came into prominence in strategic discussions in the 1950s to describe the preemptive "blunting" attack intended to destroy the enemy's nuclear capability. Measures describing the counterforce capability were a strong issue in the interservice debate over counterforce versus deterrent strategy. One side stressed the damage potential of the forces preempted, others stressed the damage to the U.S. of the residual.

- In the early 60s "damage limiting" studies evaluated a balanced mix of counterforce and other damage limiting measures, preemptive attack, ASW, ABM, bomber defense and civil defense. These studies used marginal utility in throwweight (KP) forestalled per dollar cost as an optimality criterion. The damage to the U.S. from an attack against the resulting posture was assessed. McNamara's choice of "assured destruction" as a criterion for acquisition policy followed his receipt of these studies. Alternatives, including the massive blunting attack, and a perennial "assured survival" massive defense, as well as the balanced damage limiting combination, were apparently judged beyond economical feasibility.

- The symmetry of the ICBM/ICBM confrontation encouraged analyses in the late 50s with the reassuring conclusion that there was an inherent "stability" in the fact that even if each weapon could kill a silo, reliability failures would always leave a residual. Given two equal ICBM forces, a preemptive attack would disarm the attacker faster than the defender.

- The advent of MIRV changed this picture since, in principle, one booster could preempt several. Now questions of accuracy, yield, fractionation, hardening and defense all had to be accounted for if the stability concept was to be preserved. Such analyses have been used to identify an enemy accuracy at which a given ICBM becomes "destabilizing" or a maximum "throwweight per target" acceptable given an assumed accuracy. (A typical such analysis (1969) is at Tab B with numbers deleted. A more elegant mathematical formulation is in a paper delivered by Glenn A. Kent to a recent meeting of the Military Operations Research Symposium that the Working Group might wish to solicit from the author.)

- A graphic presentation of outcomes that permits display of the relative counterforce and countervalue attack capabilities of the two sides has been widely used since the 50s. It has some value as a display of strategic balance. A one-sided example (from a '69 study) is illustrated in Tab C which concerned itself with U.S. sufficiency against a Soviet first strike. A common two-sided application of this display is the "fish curve." The concave curves of Fig. 6C in Tab A illustrate the trade-off between allocations to first strike counterforce and countervalue. In the "fish curve" these are plotted for both sides, giving a characteristic convex shape formed by the two curves. The scale is usually reversed as illustrated in Tab D. Outcomes too far (in the direction favoring the attacker) from the diagonal representing equal damage are viewed as an incentive to attack. Thus the "fatness" of the "fish" outlined by the two curves is taken to be a measure of instability.

- A similar display is valuable for other analyses where comparative advantage is the issue. Tab G excerpts methodology with permission from an unpublished study by D. Kybal which attempts to explore what force characteristics might mitigate escalatory incentives even if substantial parts of the force are targetable. Tab H illustrates related work of George Pugh interpreting these exchanges within the context of the Nash bargaining game.

- The heavy emphasis on MINUTEMAN vulnerability as an element in the ABM/SALT issues in the early 70s narrowed the focus of public interpretation of counterforce capability. Hard target kill capability expected to be deployed in the large Soviet ICBM was emphasized. Other types of counterforce target and of damage limitation were underplayed. It became conventional to infer that counterforce is the only objective of a hard target capability, and to associate both with first strike intentions.

- ° The strategic concept of limiting damage by withholding countervalue attack as an attempt to control escalation was publicly enunciated in President Nixon's early messages. These concepts were a topic of classified debate since the late fifties. They were especially germane after recognition in the mid 60s that McNamara's assured destruction was not adequate to describe the objectives of a plan for execution once the deterrent objective had failed.

- ° Further official announcements of the flexible response strategy by Defense Secretaries has occurred in recent years and been subject to considerable public debate focussing on the misconception that it represents a return to the first strike "counterforce strategy." See Tab A to Annex VI.

C. <u>Application to assessment of the overall balance and of SLBM contributions.</u>

- Specific military measures that weigh in the overall balance are discussed in Annexes A-1 through A-5.

- Damage limiting capability and the role of counterforce attack in damage limiting are the two dominant military measures most important in assessing the strategic balance and its stability.

- The importance of the contribution of counterforce capability to damage limitation is overrated as such since the many other criteria: defense, timing etc. are much less easily solved than is the laydown of a nuclear attack. Counterforce nevertheless is the dominant element in assessing stability and the balance between forces neither of which dominates. This is partly because it comprises a major nuclear attack, partly because it can be preempted by an enemy decision to use the forces at risk before he loses them. Whether or not damage limitation is feasible the incentive to escalate either to a disarming attack or to attack as an escape from a disarming threat is recognized to be strong once the inevitability of hostilities is apparent.

    -- Because of the possibility that escalation might be controlled, counterforce capability is not a symmetrical (zero sum) contribution to each side's strength in the strategic balance. Lacking the peripheral defensive imperatives that convert a counterforce capability into damage limitations, a given side derives more potential advantage from diminishing its own counterforce vulnerability than from its capability to exploit that of the other side.

- As noted in Annex A-1, hard target capability, which is the contribution to counterforce capability that most exercises forecasters currently, can be expected to have two important characteristics: Once feasible at all, it will become feasible relatively rapidly and in quantity; large numbers of weapons and high yields will become progressively less necessary.

  -- Future assessment of the balance will thus converge toward a situation where each side by choosing what fraction of its force to deploy in targetable systems will have determined the counterforce capability of the other

  -- The prospect of preempting the other side's counterforce capability if it is targetable could become attractive if it could limit the attacker's vulnerability.

° Recommendation

- It is suggested that measures of counterforce vulnerability be given preeminence in assessing the strengths of the two sides in the balance, and that only that part of counterforce attack capability that is not itself vulnerable to counterforce attack be credited as a strength. (Measure: Fraction of opposing capability at risk to non-targetable counterforce systems.)

  -- SLBM together with other future mobile missiles and quasi mobile systems such as bombers can be expected to contribute to maintaining these capabilities as the balance moves against targetable systems. Both countervalue and counterforce (including hard target) capabilities should be weighed.

  -- Breakthroughs that would make these systems targetable would upset the balance and should be carefully watched for.

ANNEX A-1

HARD TARGET KILL CAPABILITY

° Definitions

- The measure of hard target kill capability of a strategic force is the number and value of hard targets it could destroy in an attack. It depends on weapon yield, accuracy, weapon availability, reliability, reprogramming, capability, penetrability, and the number, importance and vulnerability of the targets offered at risk by the other side.

  -- Target "hardness" is measured in blast overpressure (psi) or in a Vulnerability Number (VN-K) which can reflect variation in overpressure vulnerability with weapon yield. Where such variation is present, "hardness" in psi, commonly refers to that for a 1 MT yield.

  -- Target vulnerability specifies overpressures which will damage to a given level (serious, moderate, etc.). Probabilities are expressed as PD-probability of damage rather than Pk. Target hardening specifies a "design overpressure" which the target is expected to survive. These are not the same. A vulnerability to double the design overpressure is sometimes used as an approximation for a decisive damage criterion in unclassified analyses where the specific vulnerabilities cannot be used.

  -- Weapon yields (kilotons, KT or megatons, MT) determine how far (weapon radius) from the burst point a given overpressure or VN will occur. This distance varies with the cube root of yield $Y^{1/3}$.

  -- Accuracy of weapon delivery is usually measured in CEP, the radius from desired impact point (DGZ) within which 50% of the aimed weapons are expected to fall. Guassian circular standard deviation (.85 CEP) is sometimes used.

  -- Within a strategic weapon inventory, weapons are characterized by availability (the fraction on line and alert as opposed to off-line/non-alert) and reliability (the fraction of those ordered to attack which are expected to function correctly).

  -- Reprogramming allocates weapons to compensate for reliability failures.

-- Kill probability (Pk) is the product of reliability times the probability (SSPK) that a reliable, penetrating weapon will destroy the target. If reprogramming is done, the non-reprogrammable reliability, NRPR, is the multiplier and more weapons are allocated than intended targets. (1/RPR where RPR = reprogrammable reliability.)

-- Penetration and kill probability, and probability that a weapon will be destroyed before launch (DBL), may or may not be reprogrammable depending on the scenario.

-- Damage expectancy (DE) is the assessed overall probability that a given target will be damaged taking into account all the above factors in the context of a scenario.

° Comment

- Target kill capability calculations in the military differ somewhat in detail from those in the open literature. Unclassified slide rules1/ and algorithms are available for the VN-K method which is generally used - the difficulty is unavailability of the classified VN-K for specified targets and of critical weapon parameters, notably non-reprogrammable reliability and accuracy.

- The VN-K system is described in the DIA "Green Book" which contains also classified data on vulnerabilities. The method distinguishes two primary kill mechanisms, overpressure (P-type) and dynamic pressure (Q-type) examples 20P6, 20Q6. Most "hard" targets of interest are P-type.

- It is a U.S. convention that when overpressures are used to describe vulnerability, the overpressure referred to is that associated with a 1 MT weapon. The "K" factor of the VN system (not to be confused with Kosta Tsipis' lethality parameter) describes the sensitivity of this lethal overpressure to yield. At K = 6, twice as much overpressure at 20 KT as at 1 MT would be required, for example.

1/ D.C. Kephart. Damage Probability Computer for Point Targets with P and Q Vulnerability Numbers Rand Report R-1380-PR Feb 1974.

- The following approximate formulations of the VN-K procedure for P targets were derived for convenience on a pocket calculator. The K-dependence[1/] takes the form of an adjustment to be added to the basic VN. For P targets this is D = 11 lnS where S is

$$S = \frac{1.36}{Y^{1/3}}\ \frac{K}{10} + \sqrt{\left(\frac{1.36}{Y^{1/3}}\ \frac{K}{10}\right)^2 + 1 - \frac{K}{10}} \quad \text{(Y in KT)} \qquad (1)$$

Given the newly adjusted (VN + D), the overpressure, P is

$$P = \ln^{-1} \frac{VN + D + .6}{5.48} \qquad (2)$$

An approximation to the weapon radius, WR(1) for an overpressure, P, from a 1 KT weapon, surface burst, is given by:

$$WR(1) = 1500 \left[\sqrt{P + 4.5} - \sqrt{4.5}\right]^{-2/3} \quad \text{(WR in feet)} \qquad (3)$$

At some other yield, Y, $WR(Y) = WR(1)\ Y^{1/3}$ (Y in KT)

Single shot kill probability Pk for P targets is

$$Pk = 1 - \left[1 + .1155 \left(\frac{WR(Y)}{CEP}\right)^2\right]^{-6} \qquad (4)$$

- Brown[2/] points out many of the pitfalls plaguing the careless usage of the simpler models now current in the open literature. Similar models are sometimes misused also within the defense community. If we leave aside judgments as to biassed technical estimates, the most important of these are careless attribution to a single weapon of capability to kill more than one hard target, and the neglect of fratricide, which constrains the ability of many weapons to build up a kill of a single target. Brown's most serious omission is the consideration of non-reprogrammable reliability, which, if significant, as it currently is, will dictate multiple weapon allocation to achieve high damage expectancy, fratricide notwithstanding.

1/ Equations 1 and 2 are derived from those in the DIA "Green Book," Equation 3 derives from one by John Lewis of Defense Nuclear Agency and Equation 4 from one by G. A. Opresko of the Applied Physics Laboratory, Johns Hopkins University. Coefficients in Equations 2 and 3 are the author's choice for reasonable fit to the Green Book Tables. Similar approximations for Q targets are feasible only for specified VN/K/Y ranges because S (K) is a cubic equation.

2/ Brown, Thomas A: Missile Accuracy and Strategic Lethality. SURVIVAL Vol. XVIII No. 2 Mar/Apr 1976.

- The extreme sensitivity to weapon delivery accuracy dwarfs most other aspects of hard target kill considerations. Besides increasing hit probability, a 50% decrease in CEP can retain equal probability with yields smaller by a factor of 5-8 or, at constant yield, against targets hardened by a similar multiple.

- For example, it requires the unusually disadvantageous K - factor of 9 for a 200 KT weapon to be no more effective than a 1 MT weapon of twice the CEP. This is illustrated by the following table where capabilities of such weapons against a 500 psi (42P9) and a 3600 psi (53P9) target are shown for various CEP.

SINGLE SHOT KILL PROBABILITY (SSPK)

TARGET	42P9 (500 psi)		53P9 (3600 psi)	
WEAPON	1 MT	200 KT	1 MT	200 KT
CEP (NM)				
.4	.35	.10	.10	.03
.2	.80	.35	.35	.10
.1	.99	.80	.80	.35
.05	.99	.99	.99	.80
.025	.99	.99	.99	.99

- This table illustrates the very rapid convergence to near perfect kill probability once accuracy gets into the ball park, the concurrent feasibility of fractionation into smaller MIRV and that it takes a lot of hardening to delay this process even by one step.

- DE must allow for non-reprogrammable reliability. This is the probability of arrival and functioning of a weapon which will not be substituted for, if it fails. A reliability of .85, for example would allow two weapons of SSPK .80 to achieve a .90 DE. With only one weapon per target even a perfect SSPK = 1.0 would yield no higher a DE than the non-reprogrammable reliability. Very high DE thus requires either (1) coping with fratricide or (2) undertaking the sensor and C^3 effort involved in putting more types of potential failure into the reprogrammable category.

- Kill capability is limited by the availability of targets. Overkill may contribute to assurance against reprogrammable failures such as DBL but cannot increase the number of targets at risk or their value.

- Since ballistic missiles were first deployed, the average time for deployment of a new missile with CEP reduced by half has been 4-5 years. Accuracy of SLBM has lagged that of ICBM by somewhat less than this time.

- A typical new MIRVed weapon system will be deployed in decisive numbers over a similarly short time (250 boosters with 8* weapons each give two each on 1000 targets).

- The conclusion from the above assessment is that, within the perspective of current trends, hard target capability can be assessed as either present at decisive levels or of minor consequence with a relatively brief transitional interval where gradations are an interesting qualification.

° <u>History of Target Hardening and Hard Target Kill Capability Measures</u>

- Initial deployment of hardened ICBM in the U.S. was premised on proliferation of targets to stay ahead of attack capability. The operative measure of hardness was the distance apart two silos had to be sited to escape multiple kills by a single weapon of a postulated yield. (Costs of hardening were justified by economies in real estate and communications.)

- In the late sixties, when proliferation had been foreclosed, first by decision and later by SALT, and as MIRV escalated the foreseeable threat, hardness assessments describing survivability against one-on-one attack became important. The operative measures here were improvement of active defense feasibility (intercepts could be closer to the ground) and forestalling the threat. In the latter case, a common measure was a level of Soviet CEP that would enforce redeployment to another basing mode.

- Until the early seventies measures of hard target probability admitted of accumulating the damage probability, P from each of any number, n, of weapons to give an overall probability $1 - (1 - P)^n$. Weapon counts had been too low to make this calculation very practical except in the case of a few high value targets. Only recently have forecasts of MIRV deployment given significant ratios of weapons to silos.

- At this time, the fratricide complication was highlighted. It was pointed out that subsequent weapons might not survive being destroyed by earlier arrivals. Current procedures exclude computations based on more than two or three weapons

* Cf IISS Military Balance 1975-1976 p. 73 Footnote K. (SS-18)

per target, greatly simplifying calculation. It transforms the assessment of hard target capability from a force level to a force quality question because squeezing several thousand extra weapons into 1320 MIRVed boosters is no problem. As a force quality issue, illustrated by the table above, hard target kill capability is either unavailable or easy.

- <u>Measures of the Impact of Hard Target Capability and SLBM Contribution in the Strategic Balance</u>

  - Evaluation of the strategic balance should identify the onset of hard target capability in the forces.

  - The measure of the impact of the capability once deployed is primarily the value of the targets at risk. A good measure of this value is the fraction of overall EMT or weapons that are targetable.

ANNEX A-2

MEGATONS AND EQUIVALENT MEGATONS (EMT)

° Current definitions

- A megaton is the yield of a nuclear weapon bursting with the energy of 10^6 tons of TNT explosive.

- Equivalent megatonnage (EMT) is a value such that the total blast damage done by several weapons adding to one EMT will equal that done by a single one megaton weapon. In the U.S. it is currently a convention to assess that for a weapon of yield Y, EMT = $Y^{2/3}$ for yields less than 1 MT and EMT = $Y^{1/2}$ at higher yields.

° Comment:

- The damage radius, R, to which a given level of blast damage occurs is proportional to $Y^{1/3}$. The area covered is πR^2, i.e. $\sim Y^{2/3}$. For example two weapons each having $Y^{2/3} = 1/2$ (i.e. Y = .354) will cover the same area as one having $Y^{2/3} = 1$ with damage at least as much as a given level.

- The switch to $Y^{1/2}$ at higher yields was intended to reflect the diminishing returns from overkill against cities in the context of sizing a retaliatory force. (A 1 MT weapon gives 10 psi overpressure out to 15,000 feet, a radius larger than many population clusters.)

- The amount of radiological fallout is in direct proportion to fission yield. This varies widely depending on how "clean" or "dirty" the weapon (a "clean" weapon has a higher proportion of fusion, i.e. H-bomb, reactions in its total yield). Whether use of smaller weapons to deliver a given EMT results in less overall fallout because of their lower total megatonnage depends on whether or not the smaller weapons are enough "dirtier" to cancel the effect. Fallout from surface burst weapons is deposited locally and comprises a major radiological warfare weapon threat. The fallout from airburst weapons rises and its longer-lived components (e.g. Sr^{90}) are distributed worldwide.

° History of application as a measure

- The use of $Y^{2/3}$ as a measure for scaling deterrent force size goes back in U.S. defense community evaluations at least to 1958 and probably earlier.

2

- The measure practically dominated assessment of sufficiency of U.S. weapon acquisition policy during the mid to late 60s under Mr. McNamara. His criterion of deterrent sufficiency was the capability to deliver a given total EMT with high assurance (provided by redundant forces) in the face of various threats. The $Y^{1/2}$ criterion over 1 MT was adopted in this context.

- Tab E illustrates a commonly used estimate of population fatalities vs EMT.

- At the practical level of military planning of weapon allocations to targets, EMT has never displaced other more specific measures of individual weapon capability.

- With the advent of new criteria stemming from the President's desire to have other options than massive anti-city attack, and in the context of the counterforce threat to MINUTEMAN, EMT had diminished sharply in prominence within the U.S. as a measure of U.S. or Soviet capability.

° Application as measures of overall balance and of SLBM contributions.

- Indicating as it does, the gross area covered by nuclear blast effects, EMT, or its simpler version, $Y^{2/3}$ at all yields (e.g. 25 square miles at 10 psi per EMT) is a valuable measure for public appreciation of overall magnitude of potential devastation from a nuclear exchange.

- Too many other more significant factors dominate the evaluation of the military strategic balance to give ratios of EMT much justification as indicators of advantage. A limited utility remains in EMT as a parameter where components of a force are evaluated for their relative contribution to a classical pure deterrent strategy or as damage limiting targets (see Tab A).

- Total megatonnage, and specifically fission megatonnage which is assessed as likely to be airburst in event of an exchange, is of interest as a measure of worldwide environmental impact. This has little or no value as an indicator of relative strength. Indeed, within a given force size, as fractionation and other qualitative improvements are deployed, there will be a tendency for total megaton loadings to diminish as military effectiveness increases.

- In a context of deliberate controlled response, EMT is a disadvantage for forces having the task of target destruction with minimum collateral damage - the least EMT capable of the required effect is optimal, putting a premium on accuracy.

- EMT is appropriate to assess the fraction of the overall force withheld for the purpose of threatening ultimate devastation if escalation is not controlled. It is also appropriate as an indicator of value at risk to counterforce attack.

ANNEX A-3

THROWWEIGHT/PAYLOAD/USEFUL WEIGHT (KILOPOUNDS)

° Current definitions

- Missile throwweight (KP)

  -- Missile weight exclusive of main propulsion stages. Includes guidance, bus (if MIRVed) reentry vehicles, penetration aids.

- Bomber payload

  -- Weight of expendable ordnance, includes bombs, ASMS, decoys

° Comments:

- Payload has been the basic measure of bomber capability from the beginning.

- Missile payload by analogy originally excluded guidance.

- Tradeoffs between guidance, and with MIRV, the PBCS, weaponry and penaids, etc. made the current definition more useful.

- "Fractionation" of throwweight in MIRV/MRV payloads enhances plausibility of this measure as a measure of potential capability, especially since this can be done keeping some other significant capabilities of a booster (such as EMT) unimpaired while exploiting throwweight.

- These capabilities were strictly potential - other measures such as weapon count, EMT, hard target kill potential, etc. must be specified to give throwweight a military meaning.

- For missiles of different throwweights to be meaningfully added to reflect a total potential capability requires technology to be defined in the following ways. KP per RV, for soft target capability; KP per EMT, for area coverage at a given destruction level and KP per hard target kill (involving accuracy, yield of an RV, capability to cope with fratricide, etc.).

° History of applications as a measure

- Missile payload was highlighted as an issue in the late 1950s in discussions of basing modes. Early ICBM based in clusters were recognized as undesirable because "too much payload at risk at an aimpoint." Curtailment of TITAN deployment (even signly based) in favor of MINUTEMAN was also on this basis.

- Concentration of throwweight/payload in bombers and SSB(N) is recognized as a similar vulnerability. Attack is assumed preordained in any scenario where these are targetable.

- Throwweight is a typical parameter since the early 60s in analyses within the U.S. defense community such as Damage Limiting Studies and studies which describe "stability" of the strategic balance in terms of throwweight expended in a counterforce attack versus throwweight destroyed.

° Applications as a measure of overall balance and of SLBM contributions:

  - Throwweight is a useful parameter for capability generalizations.

  - Ratio of total throwweights has no meaning as an indicator of the strategic balance, since impact is conditional both on technology (governing capability implication) and other differentiations, survivability, stability, sufficiency, etc. determining how the capability of systems affects the confrontations.

  - Like other such measures of capability (EMT/weapons/etc.) throwweight comparisons should be qualified as noted in Appendix A supra.

ANNEX A-4

NUMBERS OF WEAPONS/SNDV

- Definitions

  - Strategic weapon counts include individual MIRV reentry vehicles (R/V) and bombs and ASM in heavy bombers.

  - Tactical weapons and cruise missiles other than ASM are not currently counted as "strategic."

  - Strategic nuclear delivery vehicles (SNDV) include heavy bombers, SLBM and ICBM.

- Comment:

  - Definitions of strategic systems are artifacts of SALT.

  - Weapon count (appropriately modified by deliverability, etc.) is a good measure of potential point target attack capability, including hard target capability, once necessary accuracy is achieved.

  - Against undefended area targets (population, industrial floor space) and against complexes of nearby soft point targets, EMT is superior as a measure.

  - Against defended targets fractionation of a given EMT into a number of weapons is advantageous to counter the defenses.

  - If weapon yields in a stockpile are tailored to target requirements so as generally to require only one functioning weapon to achieve desired damage, weapon count can be assessed as a measure of target coverage.

  - Differences in SNDV types give SNDV total count little significance.

  - Assessments within the U.S. military establishment frequently measure sufficiency in terms of fractional coverage of specified target lists within a scenario. While these use detailed weapon characteristics and deliverability simulations, aggregated numbers deliverable comprise a good basis for coverage assessment. Allowance for juxtaposition, assurance through cross targeting and non-linearity of the value heirarchies within target categories can be made analytically. Coverage as a function of number tends to fall into a typical exponential saturation curve like that for population vs EMT. The difficulty for assessment outside the establishment is in estimating the parameters.

° History:

- Until the late 50s tailored yields made weapon count a good measure of damage potential albeit not a linear one because of varying target value.

- As concern for defense penetration grew during the 60s the need was perceived in the U.S. to saturate defenses and retain a penetration probability. This led to fractionation, first in MRV, then MIRV and the introduction of decoys and other penaids to augment the count of objects posed to the defense. Several generations of U.S. SLBM achieved progressively greater fractionation with no significant change in EMT (which, at the time, was the accepted measure of effectiveness).

- The Soviet Union either did not reciprocate U.S. concern for ABM penetration, chose other penetration measures than fractionation or were slower to respond.

- In the 70s, the change in U.S. declaratory policy toward flexible response threatened a spectrum of (mostly point) targets rather than solely population. In this context EMT faded as an objective and the augmented count became in its own right a measure of target coverage. This occurred notwithstanding a greatly reduced average weapon yield, which in the new context also afforded improved prospects for avoiding collateral damage.

- The ABM treaty constrains the threat which originally motivated fractionation.

° Impact on the strategic balance

- The relative weight of count and EMT as measures of strength depend both on the strategy and the opposing threat. There are differences enough between Soviet and U.S. requirements that comparisons on either measure deserve careful qualification.

- Soviet defense and U.S. non-defense of value targets makes count more significant for the U.S. than the Soviets.

- On both sides RV count is a contingent safety factor against abrogation or circumvention of the ABM treaty.

- This author does not know enough about Soviet strategy to assess the relative weight of EMT and count as a strength for their side.

-- Both counts and EMT are becoming extremely large compared with conceivable targets. The case made that hard target kill potential should be limited by the number of targets is not as cogent in arguing that counts above a target coverage sufficiency are wasted. The operative military measure is relative outcomes after conceivable scenarios have been played out. Residual numbers an enemy could expect would remain to threaten him in the post war period after he had triggered the full exchange should reinforce his distaste for further escalation.

ANNEX A-5

FLEXIBLE RESPONSE

° Definitions:

- Flexible response capability is the availability of "measured responses to aggression which bear some relation to the provocation, have prospects of terminating hostilities before general nuclear war breaks out and leave some possibility for restoring deterrence."

° Comment:

- This definition is from SECDEF Schlesinger's original exposition. This is excerpted at Tab F, which see for details.

- This capability together with the declaratory policy that signals the intention to use it weighs in the strategic balance as a military strength to the extent it could improve prospective outcomes and limit damage. It weighs as a diplomatic/political strength to the extent its extended deterrence has the effect of inhibiting coercive initiatives.

- Like a strategy of pure deterrence, flexible response relies on elements of both military strength and perceptions of it. Its suggestion of less than all-out retaliation lowers thresholds and may thus be perceived as diminishing the penalty for initiating hostilities. Its promise that whatever form hostilities take the answer will be to thwart their objective, diminishes also the prospective gain.

- Whether the perception of indomitability, of continuing capability and will, and of the promise of restraint can be sustained in the event of hostilities is the crucial judgment in assessing this aspect of the strategic balance. These capabilities depend on both quantitative and qualitative measures of the postures:

  -- Quantitative:

    °° Counterforce vulnerabilities with their strong incentives to preempt with a disarming attack. These must be not so large that they dominate choices and lead to escalations too damaging for subsequent restraint to be recognizable.

    °° Plausibility of enduring survival of an adequate withheld countervalue and flexible response capability to ensure indomitability.

-- Qualitative - whether weapons available have characteristics appropriate to condign response (to avoid undue escalation by default of restraint capabilities):

°° Variable yields

°° Accuracy

°° Penetrable singly or in small numbers

°° Adequate command and control

- Flexible response presupposes that neither economies nor the reaction of the opponent will permit a full damage limiting capability to be deployed by either side. All-out nuclear exchange would thus be so destructive as to overshadow relative advantage.

- Flexible response capability is thus the most important measure of the military balance as an indicator of relative advantage.

° History:

- See Tab E for a general review. This omits, however, SECDEF McNamara's proposal for flexible controlled response in 1963.

° Measures of impact on the strategic balance and SSBN contribution.

- Because of its infeasibility if a major escalation incentive is too strong, the principal measure of flexible response credibility is the relative immunity to nuclear counterforce. A measure of the proportion of total damage producing capability (weapons, EMT, hard target kill) at risk is an important indicator.

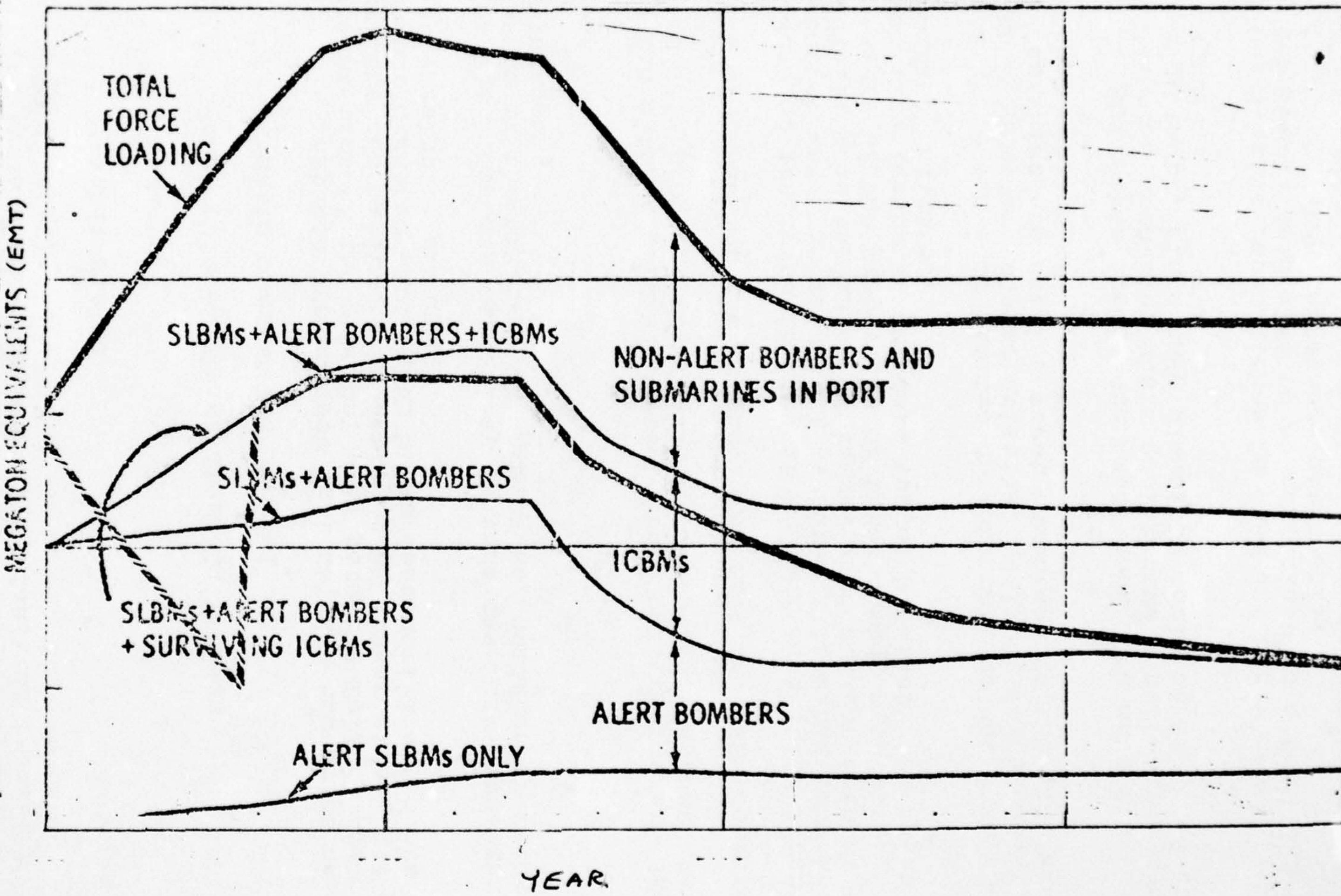
- While there are many limited options that do not make special demands on weapon characteristics, qualitative capabilities for restraint are still a great advantage to the side who has them available:

-- If targetable forces are small enough to make flexible response credible, their qualitative contribution can be a strength, since they plausibly could be expected to survive.

-- Qualitative capabilities in SLBM and other mobile components need also to be sufficient to offset incentives to preempt the targetable components.

TAB A OF APPENDIX A

US DAY TO DAY FORCE POSTURE COUNTERFORCE VULNERABILITY



TAB B TO APPENDIX A

QUANTITATIVE ANALYSIS OF A STABILITY RELATIONSHIP

1. Stability is desirable in a time of crisis when hostilities seem imminent notwithstanding deterrence. It is served by avoiding situations which offer significant relative advantages or reduce damage as a reward for preemption. For stability, one wants as little difference as possible between the relative throwweight surviving no matter which side goes first. If the difference in surviving throwweight is large, depending on who goes first, this is considered "destabilizing." If the difference is small there is little incentive for either side to initiate an attack. To this end hardening, dispersal, Hard Point Defense (HPD), and restricting the "destruction potential" contained in the silos are stabilizing influences. So also is alternative deployments to a mode that is not at risk to nuclear attack. This memorandum makes the appropriate calculations to determine payload restrictions in fixed sites to ensure that the difference will not be in favor of the attacker.

2. The difference in surviving throwweight is calculated by drawing a comparison between the throwweight required in an attack with the throwweight destroyed. We can calculate the destruction of targets by a given throwweight, given hardness, CEP, MIRV technology, and hard point defense levels. The throwweight destroyed is simply that at risk in the targets destroyed. The stability calculation will give a value of throwweight per silo that should not be exceeded if stability is to be preserved. This throwweight will vary with the parameters, thus it should not be fixed at any given level pending progressive changes to reflect technological improvements expected in CEP and MIRV technology.

3. Analysis

a. Figure I illustrates the kill potential of typical R/Vs of various yields against silos of various hardness for two CEP values typical of near-term and long-term forecasts of capability. The booster payload in KP per RV is noted based on the... Judgments are needed to determine a time period when these values apply, and to establish values for other periods.

b. Figure II converts these values into an estimate of the payload expended per silo destroyed in the first salvo of an attack.

c. Figure III expands Figure II to include the marginal cost to the enemy of each additional silo killed by subsequent salvos. It also permits estimation of the effect of a local defense based on pure subtraction (i.e. an extra salvo to sop up the defense is required for each interceptor).

d. Figure IV calculates the effect of a more sophisticated defense that permits some silos to survive with certainty.

4. Interpretation

The numbers in Figure III and IV represent the maximum payload per silo before instability as defined in the introductory paragraph would occur in the circumstances. Where the circumstances are not under U.S. control (e.g. how many salvos the Soviets choose to fire or which of a choice of RV available would be used) the minimum number in each column should be taken. These numbers are underlined for illustration (with the proviso that the corresponding HPD value should be added in the case of Table III). For example...KP is the maximum without hard point defense, reducing to...in the era when...CEP can be expected, while at a 2000 interceptor level of preferential defense...KP reducing to...KP would be the maximum.

TAB C TO APPENDIX A

EXAMPLES OF GRAPHIC PRESENTATIONS FROM A 1969 STUDY

Figure 5

Outcome Graph

PURPOSE. To discuss the fundamental graph which will be used to display the potential population kill capabilities of the U. S. and the Soviet Union.

BASIS FOR CALCULATIONS. While the outcome graph can be used to display the outcomes of a wide range of scenarios, we will for the most part display the potential outcomes of the following base case scenario:

- SU attacks fixed U. S. land-based strategic forces, reserving its mobile missiles and bombers for destruction of U. S. population.

- U. S. attacks Soviet cities with its surviving strategic forces and % Soviet population surviving is calculated.

- SU attacks U. S. cities with its withheld forces and % U. S. population surviving is calculated.

For each defined U. S. force structure and Soviet threat the above scenario will be played and the outcome plotted as a point on the outcome graph.

BASIC POINTS.

1. By playing various U. S. force structures (e.g., Policies of Pilot Study) against the high launchers levels of the NIPP Soviet threat, outcomes can be displayed and easily compared.

2. The desirability of a given force structure can be determined not only from the outcome, but also from the direction of the curve of connected outcomes on a year-to-year basis. A plot of outcomes moving to the right and remaining below some level of Soviet population surviving would, or course, be preferred trend for the U. S.

FIGURE 5

OUTCOME GRAPH

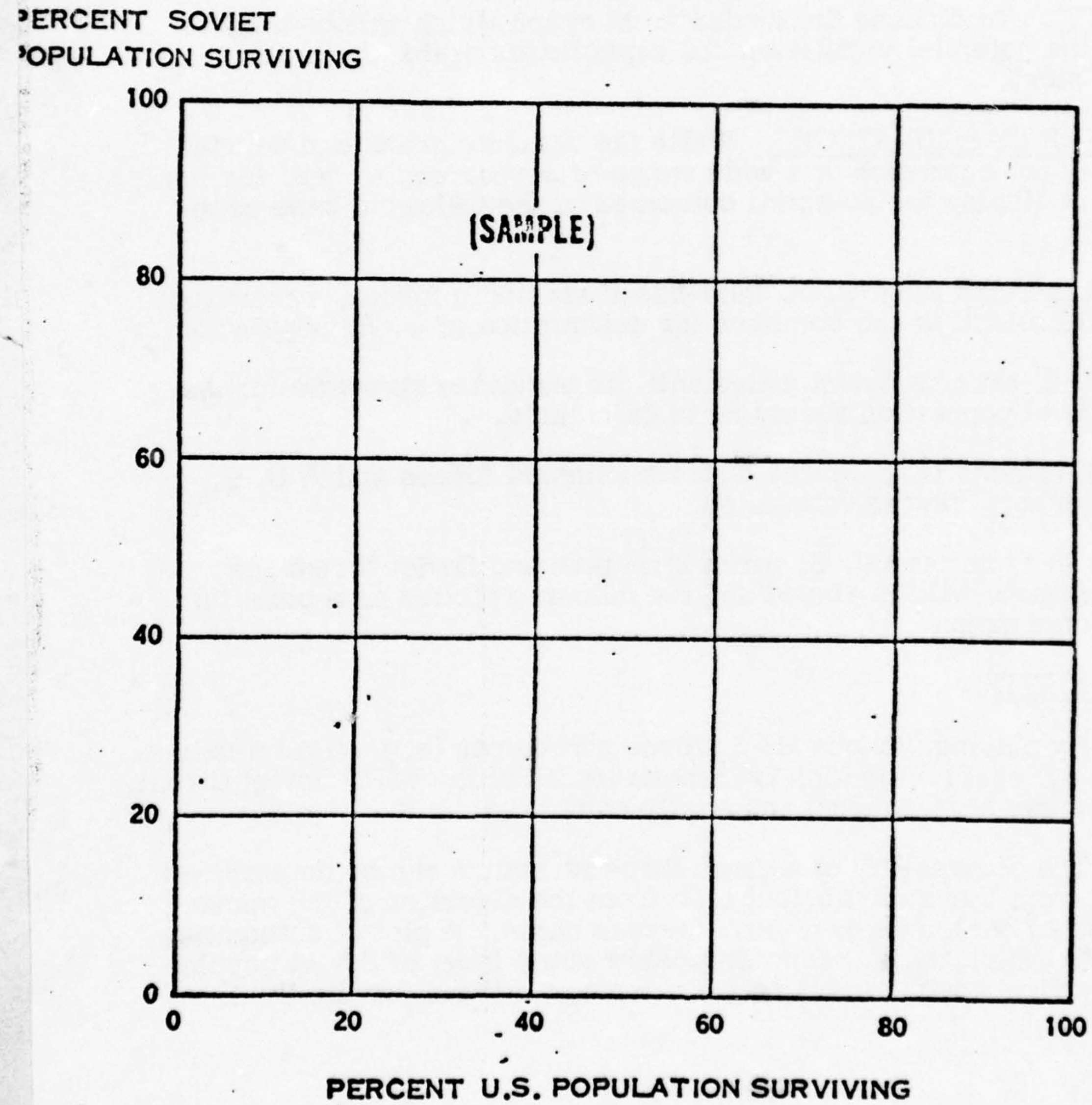


Figure 6

Exemplary Uses of Outcome Graphs

PURPOSE. To exemplify the use of the outcome graph to define military objectives.

BASIS FOR CALCULATIONS. No calculation necessary.

BASIC POINTS.

1. The objective depicted in figure 6 (a) might be designated a pure assured destruction strategy. The decision maker, by requiring the outcome to fall in the shaded area, is making the judgement that it is sufficient to destroy not less than 25% of the Soviet population under the basic scenario.

2. The objective depicted in figure 6 (b) might be designated a mixed assured destruction/damage limiting objective. Each force structure when tested against the basic scenario would have to result in an outcome falling in the shaded area in order to meet the objective. In this case U. S. population surviving is more than 80% and Soviet less than 60%.

3. Figure 6 (c) shows another use of the outcome graph -- designed by the USAF. In this particular case, the SU strikes first. At the upper right hand point on the curve, the SU has made a military attack using all of its force. As a result there is high U. S. survival rate, the only fatalities the result of collateral damage. The SU survival rate is relatively high since our fixed systems have been heavily attacked. As one proceeds in the direction of the arrow, the SU restructures its attack so that it allocates increasingly more weapons to the city or counter-value attack and less to the military or counter-force attack. Thus a wide variety of scenarios can be displayed on the outcome graph.

4. Figure 6 (d) illustrates the concept of risk associated with uncertainty in force effectiveness for U. S. forces, and possible Soviet miscalculation. Let us suppose that the U. S. has set an objective defined by the largest area shown and U. S. forces are such that the U. S. believes the most likely outcome to be at point P. At the same time, the SU, because of different factors (reliabilities, force estimates, yields, etc.), makes the same calculation and believes point Q represents the likely outcome. The U. S. would be in the situation of believeing the SU was deterred; the SU would be in a situation of believing it could "win" the war at the sacrifice of a few million Soviets and strike first. The actual outcome might be quite different but deterrence would have failed, since it is based on belief of what may happen, rather than actual outcomes

FIGURE 6

EXEMPLARY USES OF OUTCOME GRAPHS

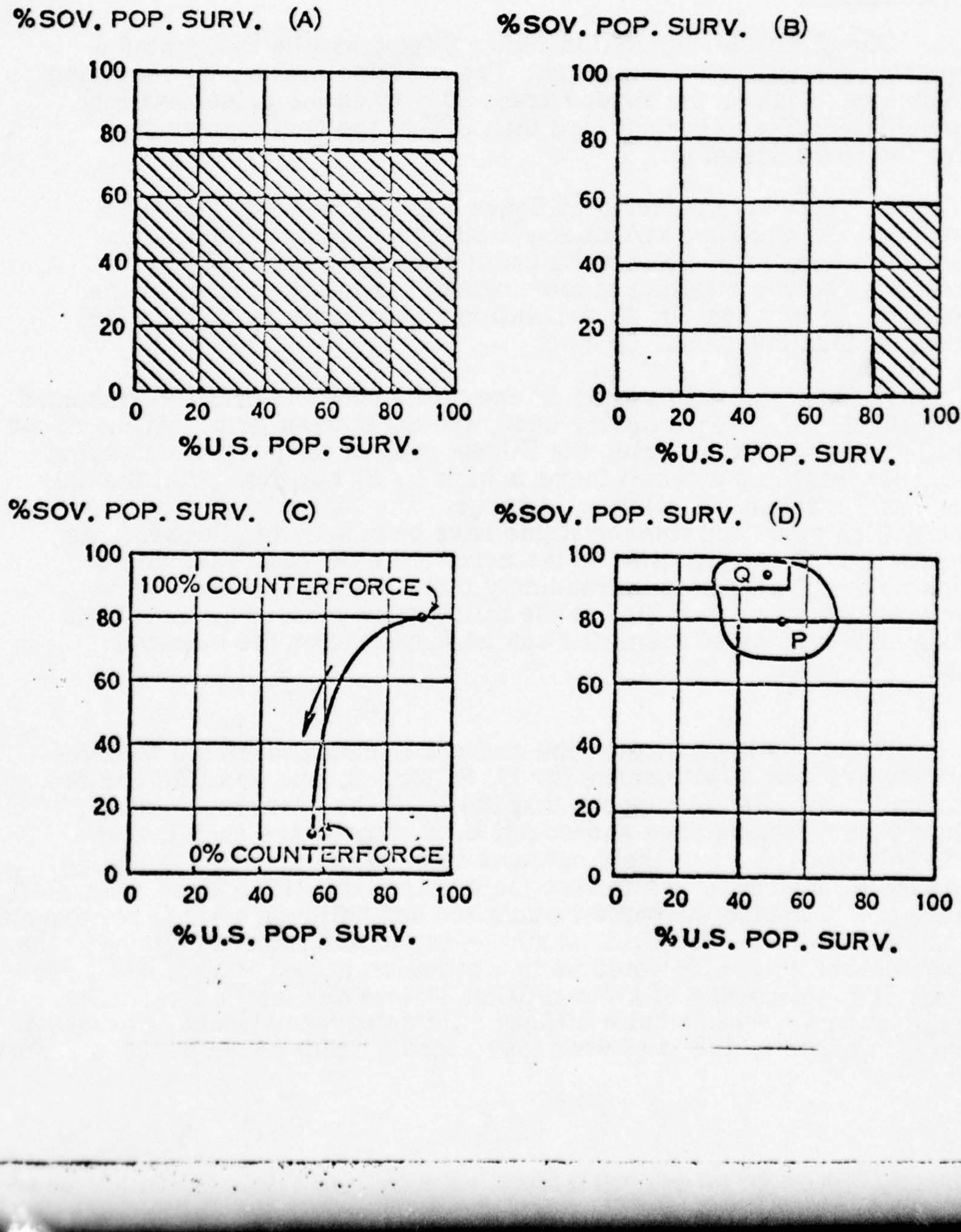


Figure 7

Outcome Graph

U. S. and Soviet Second Strike Countervalue Potential

PURPOSE. To display the historical data of figure 4 on an outcome graph format.

BASIS FOR CALCULATION. Cross plot of figure 4.

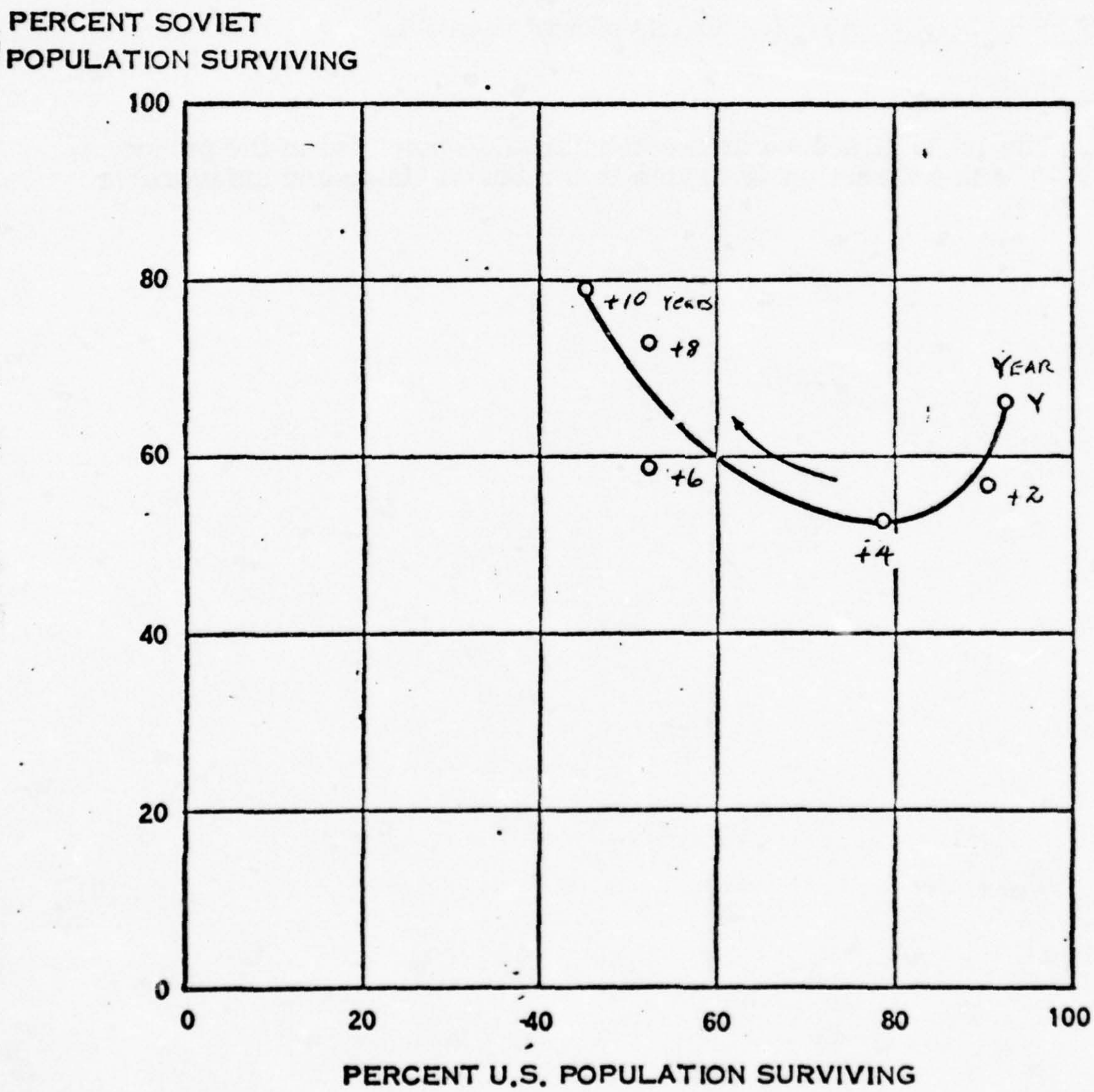
BASIC POINTS.

1. The trend of second strike countervalue potential in the period 19 -19 is in a direction favorable to the Soviet Union and unfavorable to the U. S.

FIGURE 7

U.S. AND SOVIET SECOND STRIKE COUNTERVALUE POTENTIAL

OUTCOME GRAPH

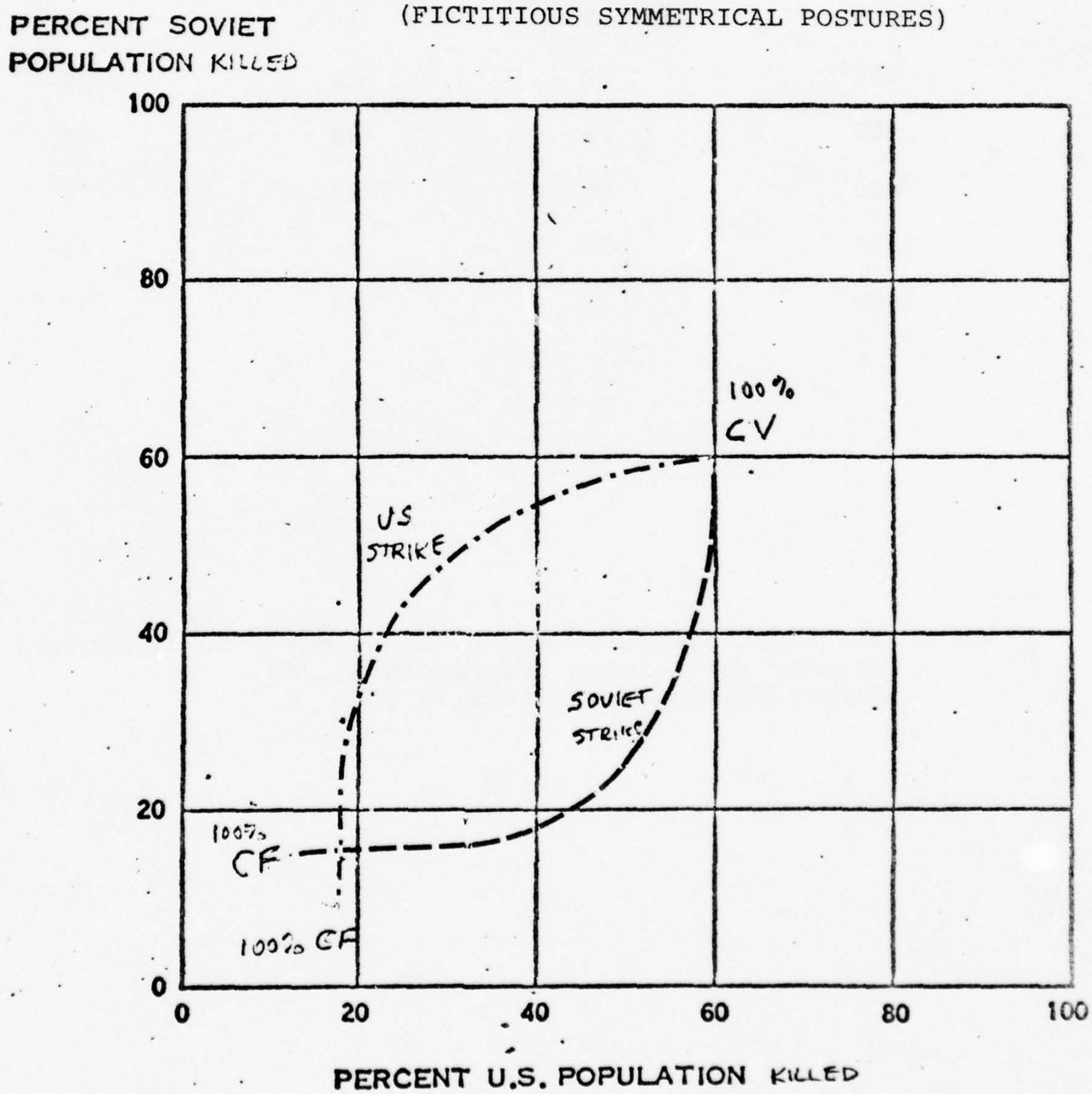


TAB D TO APPENDIX A

"FISH CURVE"

OUTCOME GRAPH

(FICTITIOUS SYMMETRICAL POSTURES)



TAB E TO APPENDIX A

SOVIET POPULATION AND INDUSTRY DESTROYED 1/

(Assumed 1972 Total Pop 247 M; Urban Pop 116 M)

1 MT Equiv. Delivered Warheads	Total Population Killed		Percent Industrial Capacity Destroyed
	Millions	%	
100	37	15	59
200	52	21	72
400	74	30	76
800	96	39	77
1200	109	44	77
1600	116	47	77

1/ From: Alain Enthoven & K. Wayne Smith, How much is Enough? Shaping the Defense Program 1961-1969 Harper Collophon, Ed 1972, P.207

TAB F TO APPENDIX A

EXCERPT FROM ANNUAL DEFENSE DEPARTMENT REPORT FY 1975

3. Deterrence and Assured Destruction

I frankly doubt that our thinking about deterrence and its requirements has kept pace with the evolution of these threats. Much of what passes as current theory wears a somewhat dated air -- with its origins in the strategic bombing campaigns of World War II and the nuclear weapons technology of an earlier era when warheads were bigger and dirtier, delivery systems considerably less accurate, and forces much more vulnerable to surprise attack.

The theory postulates that deterrence of a hostile act by another party results from a threat of retaliation. This retaliatory threat, explicit or implicit, must be of sufficient magnitude to make the goal of the hostile act appear unattainable, or excessively costly, or both. Moreover, in order to work, the retaliatory threat must be credible: that is, believable to the party being threatened. And it must be supported by visible, employable military capabilities.

The theory also recognizes that the effectiveness of a deterrent depends on a good deal more than peacetime declaratory statements about retaliation and the existence of a capability to do great damage. In addition, the deterrent must appear credible under conditions of crisis, stress, and even desperation or irrationality on the part of an opponent. And since, under a variety of conditions, the deterrent forces themselves could become the target of an attack, they must be capable of riding out such an attack in sufficient quantity and power to deliver the threatened retaliation in a second strike.

The principle that nuclear deterrence (or any form of deterrence, for that matter) must be based on a high-confidence capability for second-strike retaliation -- even in the aftermath

of a well-executed surprise attack -- is now well established. A number of other issues remain outstanding, however. A massive, bolt-out-of-the-blue attack on our strategic forces may well be the worst possible case that could occur, and therefore extremely useful as part of the force sizing process. But it may not be the only, or even the most likely, contingency against which we should design our deterrent. Furthermore, depending upon the contingency, there has been a long-standing debate about the appropriate set of targets for a second strike which, in turn, can have implications both for the types of war plans we adopt and the composition of our forces.

This is not the place to explore the full history and details of that long-standing strategic debate. However, there is one point to note about its results. Although several targeting options, including military only and military plus urban/industrial variations, have been a part of U.S. strategic doctrine for quite some time, the concept that has dominated our rhetoric for most of the era since World War II has been massive retaliation against cities, or what is called assured destruction. As I hardly need emphasize, there is a certain terrifying elegance in the simplicity of the concept. For all that it postulates, in effect, is that deterrence will be adequately (indeed amply) served if, at all times, we possess the second-strike capability to destroy some percentage of the population and industry of a potential enemy. To be able to assure that destruction, even under the most unfavorable circumstances -- so the argument goes -- is to assure deterrence, since no possible gain could compensate an aggressor for this kind and magnitude of loss.

The concept of assured destruction has many attractive features from the standpoint of sizing the strategic offensive forces. Because nuclear weapons produce such awesome effects, they are ideally suited to the destruction of large, soft targets such as cities. Furthermore, since cities contain such easily measurable contents as people and industry, it is possible to establish convenient quantitative criteria and levels of desired effectiveness with which to measure the potential performance of the strategic offensive forces. And once these specific objectives are set, it becomes a relatively straightforward matter -- given an authoritative estimate about the nature and weight of the enemy's surprise attack -- to work back to the forces required for second-strike assured destruction.

The basic simplicity of the assured destruction calculation does not mean that the force planner is at a loss for issues. On the contrary, important questions continue to arise about the assumptions from which the calculations proceed. Where, for

the sake of deterrence, should we set the level of destruction that we want to assure? Is it enough to guarantee the ruin of several major cities and their contents, or should we -- to assure deterrence -- move much further and upward on the curve of destruction? Since our planning must necessarily focus on the forces we will have five or even ten years hence, what should we assume about the threat -- that is, the nature and weight of the enemy attack that our forces must be prepared to absorb? How pessimistic should we be about the performance of these forces in surviving the attack, penetrating enemy defenses (if they exist), and destroying their designated targets? How conservative should we be in buying insurance against possible failures in performance?

Generally speaking, national policy makers for more than a decade have chosen to answer these questions in a conservative fashion. Against the USSR, for example, we tended in the 1960s to talk in terms of levels of assured destruction at between a fifth and a third of the population and between half and three-quarters of the industrial capacity. We did so for two reasons:

-- beyond these levels very rapidly diminishing increments of damage would be achieved for each additional dollar invested;

-- it was thought that amounts of damage substantially below those levels might not suffice to deter irrational or desperate leaders.

We tended to look at a wide range of threats and possible attacks on our strategic forces, and we tried to make these forces effective even after their having been attacked by high but realistically constrained threats. That is to say, we did not assume unlimited budgets or an untrammelled technology on the part of prospective opponents, but we were prudent about what they might accomplish within reasonable budgetary and technological constraints. Our choice of assumptions about these factors was governed not by a desire to exaggerate our own requirements but by the judgment that, with so much at stake, we should not make national survival a hostage to optimistic estimates of our opponents' capabilities.

In order to ensure the necessary survival and retaliatory effectiveness of our strategic offense, we have maintained a TRIAD of forces, each of which presents a different problem for an attacker, each of which causes a specialized and costly problem for his defense, and all of which together currently give us high confidence that the force as a whole can achieve the desired deterrent objective.

That, however, is only part of the explanation for the present force structure. We have arrived at the current size and mix of our strategic offensive forces not only because we want the ultimate threat of massive destruction to be really assured, but also because for more than a decade we have thought it advisable to test the force against the "higher-than-expected" threat. Given the built-in surplus of warheads generated by this force-sizing calculation, we could allocate additional weapons to non-urban targets and thereby acquire a limited set of options, including the option to attack some hard targets.

President Nixon has strongly insisted on continuing this prudent policy of maintaining sufficiency. As a result, I can say with confidence that in 1974, even after a more brilliantly executed and devastating attack than we believe our potential adversaries could deliver, the United States would retain the capability to kill more than 30 percent of the Soviet population and destroy more than 75 percent of Soviet industry. At the same time we could hold in reserve a major capability against the PRC.

Such reassurances may bring solace to those who enjoy the simple but arcane calculations of assured destruction. But they are of no great comfort to policymakers who must face the actual decisions about the design and possible use of the strategic nuclear forces. Not only must those in power consider the morality of threatening such terrible retribution on the Soviet people for some ill-defined transgression by their leaders; in the most practical terms, they must also question the prudence and plausibility of such a response when the enemy is able, even after some sort of first strike, to maintain the capability of destroying our cities. The wisdom and credibility of relying simply on the preplanned strikes of assured destruction are even more in doubt when allies rather than the United States itself face the threat of a nuclear war.

4. The Need for Options

President Nixon underlined the drawbacks to sole reliance on assured destruction in 1970 when he asked:

> "Should a President, in the event of a nuclear attack, be left with the single option of ordering the mass destruction of enemy civilians, in the face of the certainty that it would be followed by the mass slaughter of Americans? Should the concept of assured destruction be narrowly defined and should it be the only measure of our ability to deter the variety of threats we may face?"

The questions are not new. They have arisen many times during the nuclear era, and a number of efforts have been made to answer them. We actually added several response options to our contingency plans in 1961 and undertook the retargeting necessary for them. However, they all involved large numbers of weapons. In addition, we publicly adopted to some degree the philosophies of counterforce and damage-limiting. Although differences existed between those two concepts as then formulated, particularly in their diverging assumptions about cities as likely targets of attack, both had a number of features in common.

-- Each required the maintenance of a capability to destroy urban-industrial targets, but as a reserve to deter attacks on U.S. and allied cities rather than as the main instrument of retaliation.

-- Both recognized that contingencies other than a massive surprise attack on the United States might arise and should be deterred; both argued that the ability and willingness to attack military targets were prerequisites to deterrence.

-- Each stressed that a major objective, in the event that deterrence should fail, would be to avoid to the extent possible causing collateral damage in the USSR, and to limit damage to the societies of the United States and its allies.

-- Neither contained a clear-cut vision of how a nuclear war might end, or what role the strategic forces would play in their termination.

-- Both were considered by critics to be open-ended in their requirement for forces, very threatening to the retaliatory capabilities of the USSR, and therefore dangerously stimulating to the arms race and the chances of pre-emptive war.

-- The military tasks that each involved, whether offensive counterforce or defensive damage-limiting, became increasingly costly, complex, and difficult as Soviet strategic forces grew in size, diversity, and survivability.

Of the two concepts, damage-limiting was the more demanding and costly because it required both active and passive defenses as well as a counterforce capability to attack hard targets and other strategic delivery systems. Added to this was the

assumption (at least for planning purposes) that an enemy would divide his initial attack between our cities and our retaliatory forces, or switch his fire to our cities at some later stage in the attack. Whatever the realism of that assumption, it placed an enormous burden on our active and passive defenses -- and particularly on anti-ballistic missile (ABM) systems -- for the limitation of damage.

With the ratification of the ABM treaty in 1972, and the limitation it imposes on both the United States and the Soviet Union to construct no more than two widely separated ABM sites (with no more than 100 interceptors at each), an essential building-block in the entire damage-limiting concept has now been removed. As I shall discuss later, the treaty has also brought into question the utility of large, dedicated anti-bomber defenses, since without a defense against missiles, it is clear that an active defense against bombers has little value in protecting our cities. The salient point, however, is that the ABM treaty has effectively removed the concept of defensive damage limitation (at least as it was defined in the 1960s) from contention as a major strategic option.

Does all of this mean that we have no choice but to rely solely on the threat of destroying cities? Does it even matter if we do? What is wrong, in the final analysis, with staking everything on this massive deterrent and pressing ahead with a further limitation of these devastating arsenals?

No one who has thought much about these questions disagrees with the need, as a minimum, to maintain a conservatively designed reserve for the ultimate threat of large-scale destruction. Even more, if we could all be guaranteed that this threat would prove fully credible (to friend and foe alike) across the relevant range of contingencies -- and that deterrence would never be severely tested or fail -- we might also agree that nothing more in the way of options would ever be needed. The difficulty is that no such guarantee can be given. There are several reasons why any assurance on this score is impossible.

Since we ourselves find it difficult to believe that we would actually implement the threat of assured destruction in response to a limited attack on military targets that caused relatively few civilian casualties, there can be no certainty that, in a crisis, prospective opponents would be deterred from testing our resolve. Allied concern about the credibility of this particular threat has been evident for more than a decade. In any event, the actuality of such a response would be utter folly except where our own or allied cities were attacked.

Today, such a massive retaliation against cities, in response to anything less than an all-out attack on the U.S. and its cities, appears less and less credible. Yet as pointed out above, deterrence can fail in many ways. What we need is a series of measured responses to aggression which bear some relation to the provocation, have prospects of terminating hostilities before general nuclear war breaks out, and leave some possibility for restoring deterrence. It has been this problem of not having sufficient options between massive response and doing nothing, as the Soviets built up their strategic forces, that has prompted the President's concerns and those of our Allies.

Threats against allied forces, to the extent that they could be deterred by the prospect of nuclear retaliation, demand both more limited responses than destroying cities and advanced planning tailored to such lesser responses. Nuclear threats to our strategic forces, whether limited or large-scale, might well call for an option to respond in kind against the attacker's military forces. In other words, to be credible, and hence effective over the range of possible contingencies, deterrence must rest on many options and on a spectrum of capabilities (within the constraints of SALT) to support these options. Certainly such complex matters as response options cannot be left hanging until a crisis. They must be thought through beforehand. Moreover, appropriate sensors to assist in determining the nature of the attack, and adequately responsive command-control arrangements, must also be available. And a venturesome opponent must know that we have all of these capabilities.

Flexibility of response is also essential because, despite our best efforts, we cannot guarantee that deterrence will never fail; nor can we forecast the situations that would cause it to fail. Accidents and unauthorized acts could occur, especially if nuclear proliferation should increase. Conventional conflicts could escalate into nuclear exchanges; indeed, some observers believe that this is precisely what would happen should a major war break out in Europe. Ill-informed or cornered and desperate leaders might challenge us to a nuclear test of wills. We cannot even totally preclude the massive surprise attack on our forces which we use to test the design of our second-strike forces, although I regard the probability of such an attack as close to zero under existing conditions. To the extent that we have selective response options -- smaller and more precisely focused than in the past -- we should be able to deter such challenges. But if deterrence fails, we may be able to bring all but the largest nuclear conflicts to a rapid conclusion before cities are struck. Damage may thus be limited and further escalation avoided.

I should point out in this connection that the critics of options cannot have the argument both ways. If the nuclear balance is no longer delicate and if substantial force asymmetries are quite tolerable, then the kinds of changes I have been discussing here will neither perturb the balance nor stimulate an arms race. If, on the other hand, asymmetries do matter (despite the existence of some highly survivable forces), then the critics themselves should consider seriously what responses we should make to the major programs that the Soviets currently have underway to exploit their advantages in numbers of missiles and payload. Whichever argument the critics prefer, they should recognize that:

- inertia is hardly an appropriate policy for the United States in these vital areas;

- we have had some large-scale pre-planned options other than attacking cities for many years, despite the rhetoric of assured destruction;

- adding more selective, relatively small-scale options is not necessarily synonymous with adding forces, even though we may wish to change their mix and improve our command, control, and communications.

However strong in principle the case for selective options, several questions about it remain. What kinds of options are feasible? To what extent would their collateral effects be distinguishable from those of attacks deliberately aimed at cities? And what are their implications for the future size and composition of our strategic forces and hence for our arms control objectives in this realm?

Many of the factors bearing on these questions will become more evident later in this statement. It is worth stressing at this point, however, that targets for nuclear weapons may include not only cities and silos, but also airfields, many other types of military installations, and a variety of other important assets that are not necessarily collocated with urban populations. We already have a long list of such possible targets; now we are grouping them into operational plans which would be more responsive to the range of challenges that might face us. To the extent necessary, we are retargeting our forces accordingly.

Which among these options we might choose in a crisis would depend on the nature of an enemy's attack and on his objectives. Many types of targets can be pre-programmed as options -- cities, other targets of value, military installations of many different kinds, soft strategic targets, hard strategic targets. A number

of so-called counterforce targets, such as airfields, are quite soft and can be destroyed without pinpoint accuracy. The fact that we are able to knock out these targets -- counterforce though it may be -- does not appear to be the subject of much concern.

In some circumstances, however, a set of hard targets might be the most appropriate objective for our retaliation, and this I realize is a subject fraught with great emotion. Even so, several points about it need to be made.

-- The destruction of a hardened target is not simply a function of accuracy; it results from the combined effects of accuracy, nuclear yield, and the number of warheads applied to the target.

-- Both the United States and the Soviet Union already have the necessary combinations of accuracy, yield, and numbers in their missile forces to provide them with some hard-target-kill capability, but it is not a particularly efficient capability.

-- Neither the United States nor the Soviet Union now has a disarming first strike capability, nor are they in any position to acquire such a capability in the foreseeable future, since each side has large numbers of strategic offensive systems that remain untargetable by the other side. Moreover, the ABM Treaty forecloses a defense against missiles. As I have already noted in public: "The Soviets, under the Interim Offensive Agreement, are allowed 62 submarines and 950 SLBM launchers. In addition, they have many other nuclear forces. Any reasonable calculation would demonstrate, I believe, that it is not possible for us even to begin to eliminate the city-destruction potential embodied in their ICBMs, let alone their SLBM force."

The moral of all this is that we should not single out accuracy as some sort of unilateral or key culprit in the hard-target-kill controversy. To the extent that we want to minimize unintended civilian damage from attacks on even soft targets, as I believe we should, we will want to emphasize high accuracy, low yields, and airburst weapons.

To enhance deterrence, we may also want a more efficient hard-target-kill capability than we now possess: both to threaten specialized sets of targets (possibly of concern to allies) with a greater economy of force, and to make it clear to a potential

enemy that he cannot proceed with impunity to jeopardize our own system of hard targets.

Thus, the real issue is how much hard-target-kill capability we need, rather than the development of new combinations of accuracy and yield per se. Resolution of the quantitative issue, as I will discuss later, depends directly on the further evolution of the Soviet strategic offensive forces and on progress in the current phase of the Strategic Arms Limitation Talks.

In the meantime, I would be remiss if I did not recommend further research and development on both better accuracy and improved yield-to-weight ratios in our warheads. Both are essential whether we decide primarily on high accuracy and low yields or whether we move toward an improved accuracy-yield combination for a more efficient hard-target-kill capability than we now deploy in our missiles and bombers. Whichever way we go, we have more need than the Soviets for increased accuracy because of our constrained payloads and low-yield MIRVs which have resulted from our lower missile throw-weights.

With a reserve capability for threatening urban-industrial targets, with offensive systems capable of increased flexibility and discrimination in targeting, and with concomitant improvements in sensors, surveillance, and command-control, we could implement response options that cause far less civilian damage than would now be the case. For those who consider such changes potentially destabilizing because of their fear that the options might be used, let me emphasize that without substantially more of an effort in other directions than we have any intention of proposing, there is simply no possibility of reducing civilian damage from a large-scale nuclear exchange sufficiently to make it a tempting prospect for any sane leader. But that is not what we are talking about here. At the present time, we are acquiring selective and discriminating options that are intended to deter another power from exercising any form of nuclear pressure. Simultaneously, as I shall discuss later, we and our allies are improving our general purpose forces precisely so as to raise the threshold against the use of any nuclear forces.

5. Separability of Targeting Doctrine and Sizing of Forces

The evolution in targeting doctrine is quite separable from, and need not affect the sizing of the strategic forces. It is quite feasible to have the foregoing options within the limits set by the ABM Treaty and the Interim Agreement on offensive forces. What is more, none of the options we are adopting and none of the programs we are proposing for research and development

need preclude further mutually agreed constraints on or reductions in strategic offensive systems through SALT. If the Soviets are prepared to reduce these arsenals in an equitable fashion, we are prepared to accommodate them. In fact, I can say that we would join in such an effort with enthusiasm and alacrity.

To stress changes in targeting doctrine and new options does not mean radical departures from past practice. Nor does it imply any possibility of acquiring a first strike disarming capability. As I have repeatedly stated, both the United States and the Soviet Union now have and will continue to have large, invulnerable second-strike forces. If both powers continue to behave intelligently and perceptively, the likelihood that they would unleash the strategic forces is so low that it approaches zero. We are determined, nonetheless, to have credible responses at hand for any nuclear contingency that might arise and to maintain the clear ability to prevent any potential enemy from achieving objectives against us that he might consider meaningful. The availability of carefully tailored, pre-planned options will contribute to that end. They do not invite nuclear war; they discourage it.

I repeat, we are eager to begin a reduction of the strategic forces by mutual agreement and on terms of parity. That is our first preference. We would be quite content if both the United States and the Soviet Union avoided the acquisition of major counterforce capabilities. But we are troubled by Soviet weapons momentum, and we simply cannot ignore the prospect of a growing disparity between the two major nuclear powers. We do not propose to let an opponent threaten a major component of our forces without our being able to pose a comparable threat. We do not propose to let an enemy put us in a position where we are left with no more than a capability to hold his cities hostage after the first phase of a nuclear conflict. And certainly we do not propose to see an enemy threaten one or more of our allies with his nuclear capabilities in the expectation that we would lack the flexibility and resolve to strike back at his assets (and those of any countries supporting the threat) in such a way as to make his effort both high in cost and ultimately unsuccessful.

How we proceed on these counts will depend on the USSR. But I do not believe that we can any longer delay putting our potential countermeasures into research and development. The Soviets must be under no illusion about our determination to proceed with whatever responses their actions may require. And if we undertake the programs that I shall discuss later, the prospects for misunderstanding should be low. More sensible arrangements for both parties may then be feasible.

UNCLASSIFIED

STAGED C.F. EXCHANGE (U)

SITUATION

- GRAVE CRISIS CIRCA 1985
- U.S.-USSR CONFRONTATION
- POSSIBLE NONSTRATEGIC SOVIET AGGRESSIVE MOVES

OBJECTIVES

- EXECUTION OF C.F. L.S.O.'s WITHIN MILIEU OF STAGED ATTACKS

  DESIRED TO:

  * DEMONSTRATE U.S. WILL TO RESPOND TO SOVIET PROVOCATIONS/MILITARY MOVES WHICH IMPERIL VITAL U.S. NATIONAL SECURITY INTERESTS
  * PROVIDE RATIONAL RESPONSE WHILE RETAINING U.S. ASSURED DESTRUCTION CAPABILITY
  * INDUCE SOVIET TO TERMINATE EARLY CRISIS/WAR ON TERMS ACCEPTABLE TO U.S.
  * AVOID INCENTIVE FOR CONFLICT ESCALATION

STAGED C.F. EXCHANGES (U)

DEFINITION

- TIME SEQUENCED EXCHANGES
- MILITARY TARGETS ONLY (UP TO NOW EMPHASIS ON SILOS)
- NO LIMITED COUNTERVALUE ATTACK
- THREAT/EXECUTION OF ALL-OUT CV LAST MOVE
- LIMITED GAIN OBJECTIVE

RATIONALE

- STAGED INSTEAD OF ALL-OUT COUNTERFORCE ATTACKS MOTIVATED BY DESIRE TO:
  - * AVOID L.O.W.--WOULD LEAD TO CV ESCALATION
  - * AVOID FRATRICIDE--HIGH MIRVed MSLs MAKE ALL OUT C.F. INFEASIBLE
  - * AVOID EARLY EXPENDITURES OF NUCLEAR ARSENAL--SEEK WAR TERMINATION AT LOW EXCHANGES LEVELS

FEATURES OF MUSTEX MODEL (U)

- STRIKES ARE COUNTERFORCE
- EVALUATION IS OF COUNTERVALUE POTENTIAL AT EACH STAGE

WEAPONS

IBMs/SLBMs/ABMs (AREA & TERMINAL)

BEING ADAPTED TO:

* ALCMs/SLCMs
* SRAMs/SCADs
* GRAVITY BOMBS
  - AIR DEFENSES (INTERCEPTORS & SAMs)

WEAPON PARAMETERS

YIELD (EMT)

CEP, H, pk

RELIABILITY

REPROGRAMABILITY

FORCE LEVEL

MISSILE RANGE

CONSTRAINTS

ASW

IMPERFECT INTELLIGENCE

FRATRICIDE

TARGETS

CATEGORY (VN)

LOCATION (BY ZONE)

POPULATION COLLOCATION

MUSTEX - THE CONCEPT (U)

- MUSTEX COMPUTES OPTIMAL & MUTUALLY ENFORCEABLE FORCE ALLOCATION AT EACH STAGE OF WAR.
- DETERMINES STOPPING POINT, i.e., NO. OF STAGES & RELATED C.V. DAMAGE POTENTIAL FOR BOTH SIDES--NO LAND-BASED C.F. TGTs.
- SUCCESS OF WAR OUTCOME MEASURED IN TERMS OF DIFFERENTIAL COUNTERVALUE POTENTIAL AVAILABLE AT THE CONCLUSION OF COUNTERFORCE EXCHANGES (*INITIATOR'S OBJECTIVE TO MAXIMIZE* THIS DIFFERENCE, RETALIATOR TO MINIMIZE).

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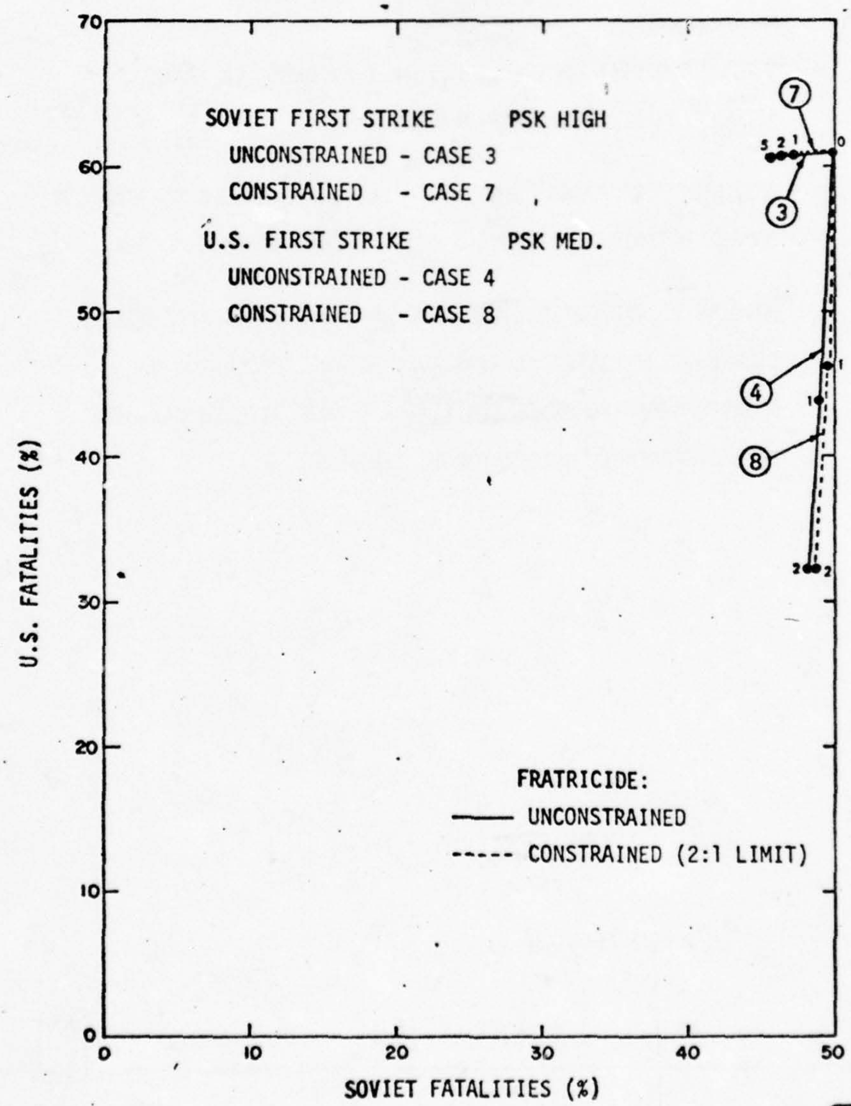
STAGED C.F. EXCHANGE COMPARISON (U)



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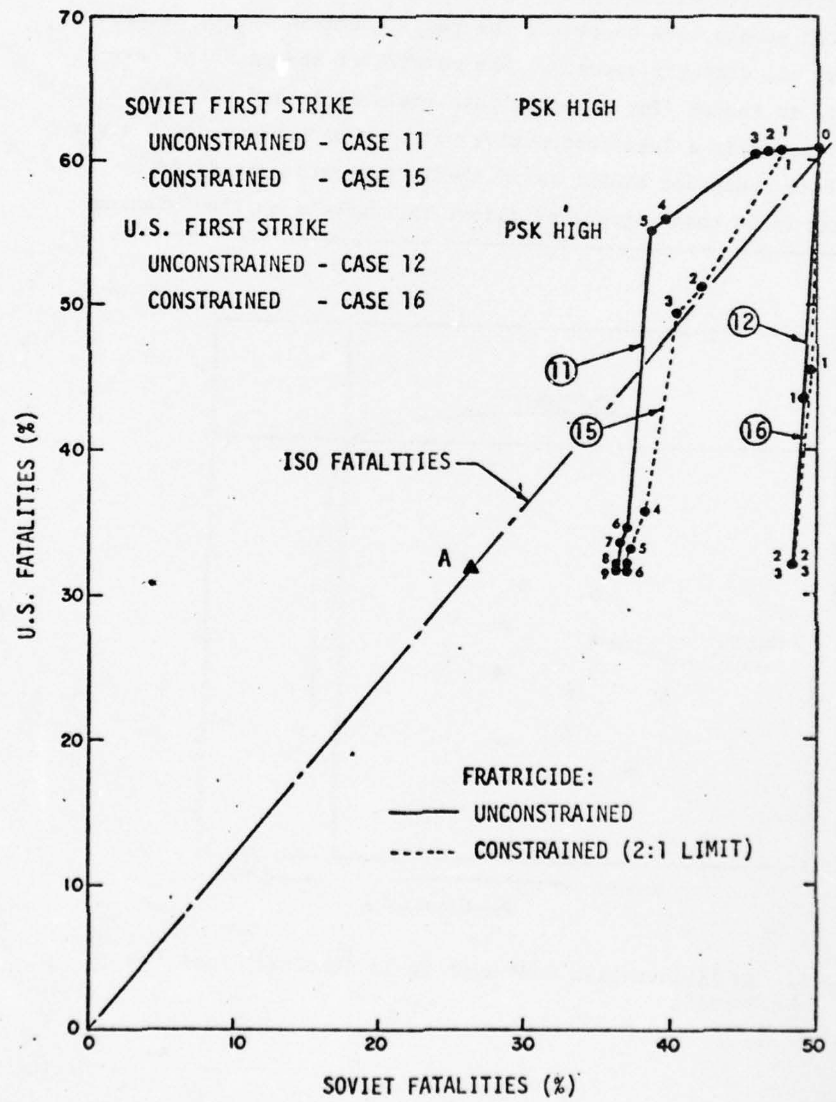
STAGED C.F. EXCHANGE COMPARISON (U)



UNCLASSIFIED

TAB H TO APPENDIX A

EXCERPT FROM AN UNFINISHED STUDY OF STRATEGIC BALANCE

It is notable that the Nash bargaining game provides a simple and intuitively attractive explanation of a paradox in wartime behavior. As many thoughtful people have observed, the real interests of two nations at war are not all directly opposed. The parties to the conflict have some interests in common (for example, both could be better off with a peaceful settlement or a less destructive war). Nevertheless, once a war has started both sides act almost as if their interests were directly opposed. They focus their attention almost exclusively on the "winning

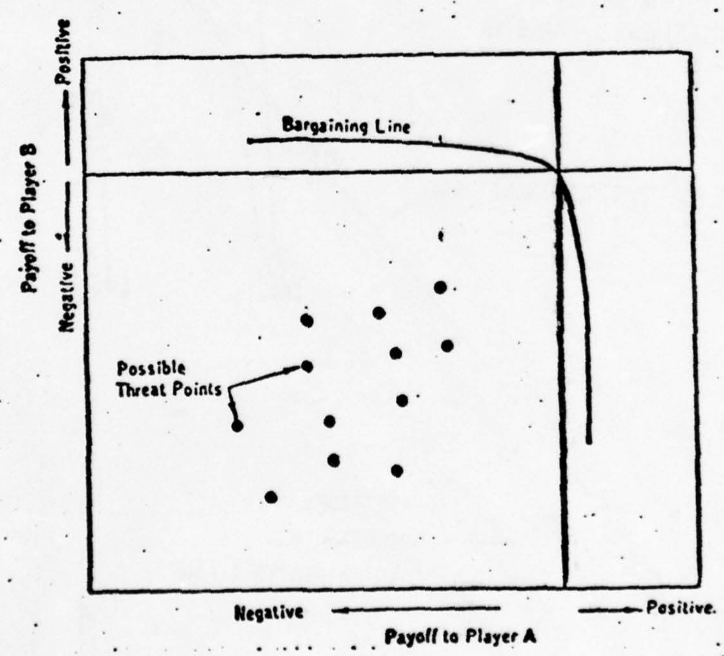


Figure 5. An Illustrative Game with Small (Limited) Positive Payoffs

the war" objective. According to common sense, the most effective way to win a war is to hurt the opponent more than he can hurt you, i.e., to act as if the war has a zero-sum payoff in which the opponent's loss is your gain. The Nash theory provides a mathematical explanation showing why such strange behavior is in fact a rational combat strategy. In reality, most wars (with a few notable exceptions) are actually limited wars that are fought within the bounds of certain mutually accepted ground rules, e.g., medieval respect for holy days and holy places, recognition of "open cities" in World War I, political limitations applied by the U.S. in Korea and South Vietnam, and the non-use of nuclear weapons in recent limited wars (although threats were made by the U.S. to hasten the Korean Armistice - Ref. 4). The bounds defined by such conventions notwithstanding, nations at war in general tend to act as if the conflict had a zero-sum payoff.

To adapt the Nash bargaining theory realistically to the LSO concept we must give consideration to the types of conventions applicable to LSO activities that may limit potential escalation. Two such conventions have already been mentioned. First, the ultimate countervalue strike may be withheld so that it can continue to serve as a threat. Second, LSO missions may be structured to minimize or limit collateral damage. Both of these limits are obviously advantageous if observed by both sides, but it is probably more important that they are also called for on each side simply as a matter of optimal play in the bargaining game. Collateral fatalities tend to dilute the bargaining utility of LSO. If either side were to do really serious countervalue damage to the other during the course of an LSO exchange he would not only increase the risk of escalatory response (possible countervalue) but he would also reduce the magnitude of his own deterrent threat.*

*The effect of such premature countervalue damage is essentially equivalent to the killing of hostages. If fewer hostages remain, their deterrent value may be lower.

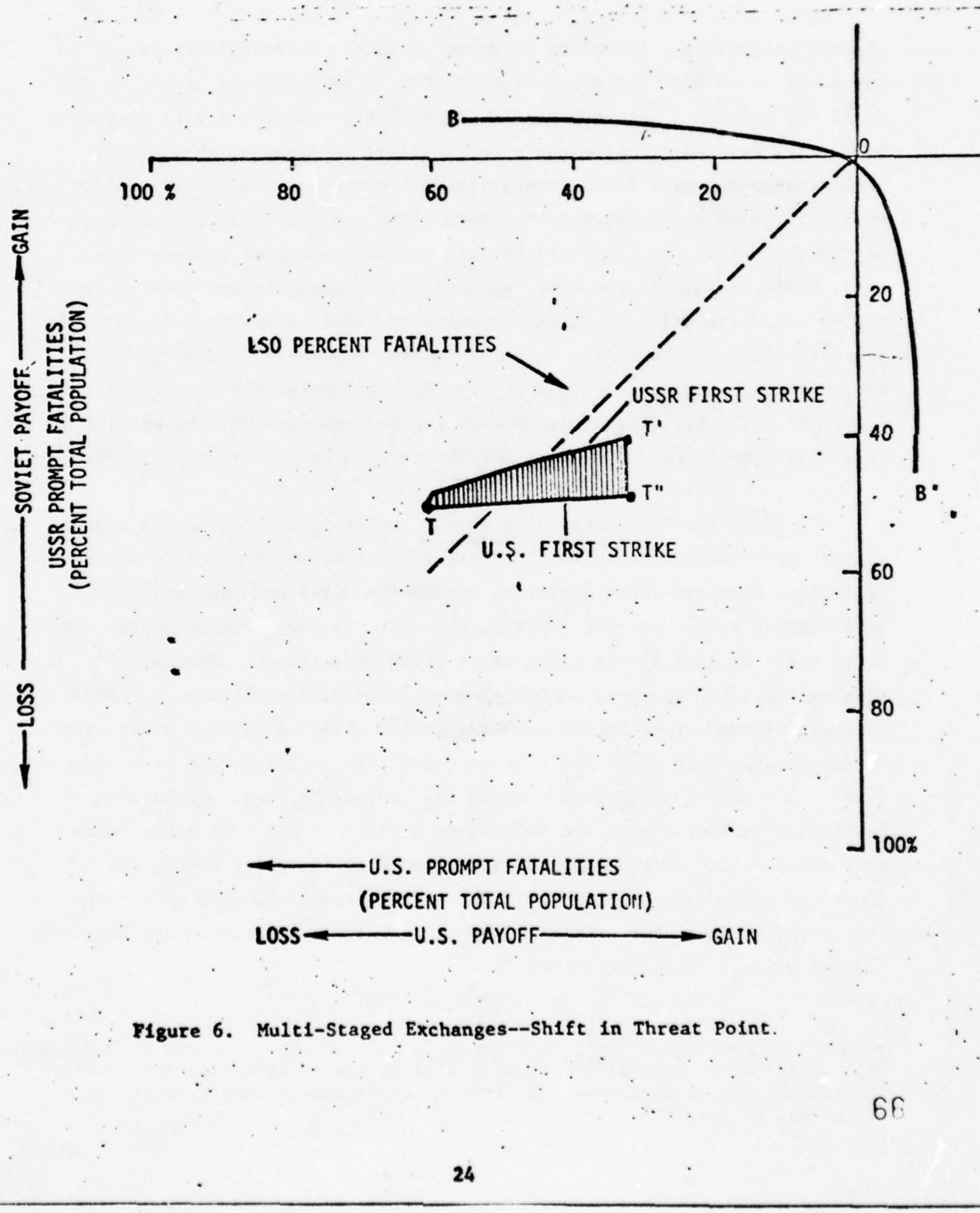


Figure 6. Multi-Staged Exchanges--Shift in Threat Point.

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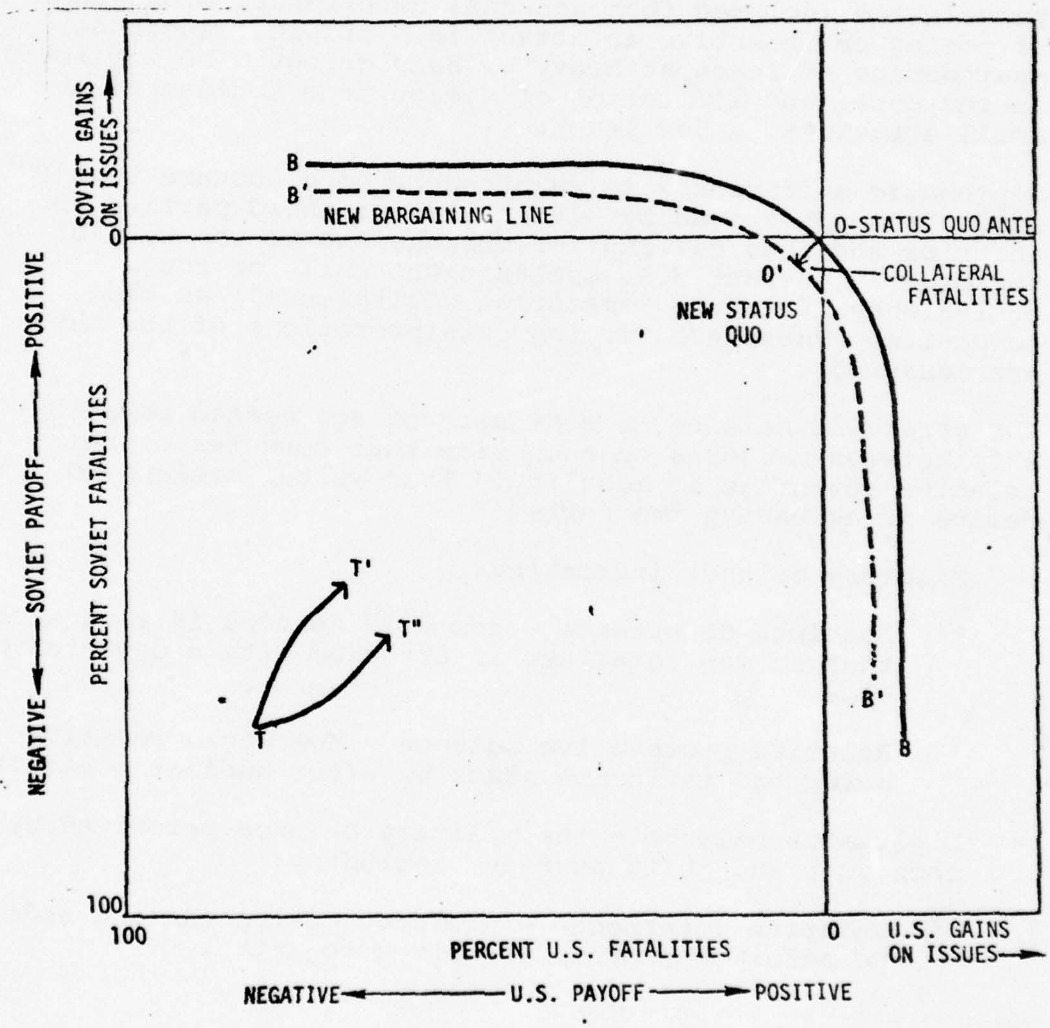

Figure 7. Collateral Fatalities from LSO Shifts Origin and Bargaining Line

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APPENDIX B

MEASURES OF OVERALL BALANCE/MILITARY SUFFICIENCY/DIPLOMATIC SUFFICIENCY/RELATIVE STRENGTHS

° Definitions:

- Military sufficiency is maintenance of a posture capable of coping with a nuclear attack and coming out better or no worse than the attacker. Its formal definition when promulgated included four aspects: deterrence, avoidance of posing an incentive to attack in a crisis, assurance that damage at least as heavy or heavier could be inflicted in response, and limitation of damage from accidental or small attacks to a low level.

- Diplomatic sufficiency is maintenance of a posture that will not be perceived by either side or third parties as inferior and thus calling for concessions to the will of the other. Current U.S. declarations call for rough equivalency (formerly "essential equivalence") as the requisite. There are varying interpretations of how these are measured.

- The strategic balance is some sort of aggregated relationship between measures on each side that connotes overall relative advantage or equality. This writer prefers to define it as having two parts.

  -- Military balance indicating:

    °° Absolute deterrence - how well assured is each side that it can retaliate if attacked with a devastating blow.

    °° Relative prospective outcome - how would relative power and influence stack up after nuclear hostilities.

  -- Diplomatic balance - the military balance perceived by each side and third parties, including:

    °° Relative deterrence - how provocative can one side be before the other is driven to attack.

° Comment

- The military and diplomatic aspects interact. Deterrence is a political reaction to relative prospective military outcomes, as are other coercive diplomatic pressures.

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- Perceptions of the military balance:
  - -- May not be realistic or shared.
  - -- Are arbitrary and subject to fashion and bias
  - -- Will tend to rely on simple measures
  - -- Are important
- It is a legitimate exercise to try to influence these perceptions.
  - -- Toward realistic assessment of military factors.
  - -- Away from biasses that excerbate instabilities.
- There is a paradox inherent in the demands of current negotiating strategy on both sides to demonstrate a unilateral disadvantage that calls for compensation. This conflicts with the objective to demonstrate relative advantage for diplomatic purposes.
- Once the negotiating purposes are served the two sides will presumably be eager to minimize the impact of the factors they have overemphasized. Both as a service to them and to objective public appreciation of the balance, the assessment should scrupulously avoid emphasis on publicly emphasized measures beyond their demonstrable military significance.
- Most important aspects of military sufficiency are discussed in Appendix A. The relevance of individual quantifiable numbers to relative strengths are shown to differ between the sides and involve contradictions that make invidious comparison of many static measures irrelevant to the balance of strengths. This is demonstrably the case for those measures currently highlighted.
- These are, for the U.S. side:
  - -- ICBM throwweight (2 or 4 to 1)
  - -- ICBM silos (1.5 to 1)
  - -- SLBM (agreed in 1972) 950 to 710
  - -- SSBN (agreed in 1972) 65 to 42

- The Soviet claims of inequity in U.S. favor include:
  - -- Forward basing of strategic SSBN.
  - -- Deployment of aircraft carriers and submarines within range of Soviet targets.
  - -- Forward deployment of weapons on allied territory.
- It would more closely reflect the military prospects to identify the relative ICBM balance as one which enhances relative counterforce potential (once guidance accuracy reaches maturity) in favor of the U.S., since ths Soviets have a much greater fraction of total throwweight and weapons in targetable systems.
- It would similarly be realistic to acknowledge that SLBM and other mobile system deployment by either side is a contribution to stability and, in this respect at least, is a benefit to both.

° History

- The notion of U.S. strategic superiority as a diplomatic strength dates from the first A-bomb.
- Since the advent of Soviet second strike capability the question of how far such an advantage could be pushed has always been a subject of controversy. However, public interpretation of U.S. superiority as a strength confirmed it as an element of U.S. status quite aside from military realities.
- McNamara's finding that damage limiting was infeasible and that deterrence rather than superiority took priority was made in a context that suggested no insurmountable challenge to U.S. retaining superiority.
- U.S. "failure" to keep pace with the Soviet buildup was a considered policy grounded in a judgment that a sufficiently well hedged response capability was enough. This objective rather than retaining "superiority" governed acquisition policy (as distinguished from employment plans).
- In 1969, the new Nixon administration reconfirmed these judgments. The declaratory "sufficiency" objective enlarged on McNamara's deterrent to include more specifics. The emphatic stress on survivability of MINUTEMAN in the ABM debates interpreted Soviet momentum as a threat to second strike capability, not to "superiority."

- It was developments in SALT that brought numerical superiority back into the public consciousness as an element of advantage. This was inevitable because it was fruitless to negotiate about aspects of forces that were not observable and verifiable by acceptable (national) means. Under this constraint the negotiable agenda incorporated controls progressively less relevant to actual military strengths. As negotiations converged on agreement public awareness gave political prominence to perceived inequities in these artificial measures.

° Measures of the overall balance and of SSBN contribution

- There are two phases required for cogent appraisal of the overall military balance. These use measures in a different way.

  -- Test the likelihood of one or the other side achieving full damage limiting capability that could dominate the balance.

  -- Measurement (in the absence of dominance) of relative capabilities to coerce advantageous outcomes. Significant advantage requires limiting hostilities short of the full mutually suicidal exchange. Advantage to one side is not the inverse of disadvantage to the other.

- A first or second strike damage limiting capability, if enjoyed by one of the two sides, would dominate the balance.

  -- A first strike damage limiting capability on both sides would be highly unstable since the advantage would accrue to the initiator. Each side, recognizing this, would fear preemption by the other.

  -- The precautionary check for dominance involves a complex of factors. Damage limiting requires that at least the following must each occur:

    °° Missile accuracy for disarming ICBM.

    °° A breakthrough converting ASW from attritive to an effective preemptive form and/or a successful breakout from ABM treaty constraints on defense.

    °° Effective bomber preemption or defense.

    °° Effective civil defense.

    °° Failure of the other side to diversify sufficiently to circumvent these measures.

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-- Measures involved are largely qualitative and defensive. So far as offensive systems are concerned they rely rather more on qualitative weaknesses exhibited by the opponent than own offensive strengths.

- Restraint and a flexible response strategy designed to induce termination of hostilities short of the countervalue exchange may be more effective potentially than active or defensive damage limitation. A posture which invites attack so heavy as to make restraint unrecognizable will foreclose a strategy of restraint.

- Measures of relative strength in the absence of dominance include considerations of:

  -- Flexible response capability derives primarily from three force characteristics:

    °° Absence of counterforce vulnerability so conspicuous as to invite escalation beyond control.

    °° Enduring survival of an indomitable countervalue force of adequate size.

    °° Survivable C^3 of adequate capacity.

  -- Additional qualitative characteristics, especially flexible weapons for condign response, significantly reinforce the primary strengths.

° Recommended measures

- Measures indicating relative strengths are illustrated in Annex A.

  -- Relative weapons/EMT in targetable basing modes, qualified by time phasing of opposing hard target kill acquisition - measure of escalatory incentive.

  -- Non-targetable counterforce capability (accurate weapons scaled to opposing target counts) - measure of escalatory disincentive.

  -- Withheld countervalue non-targetable, and otherwise survivable (against attrition threats) EMT/weapons - measure of transattack deterrence and negotiating leverage.

- Annex B illustrates the more conventional direct comparisons which impact only peripherally on the overall balance.

ANNEX B-1

EXAMPLE OF PROPOSED MEASURE OF MILITARY BALANCE

The following table, Table 1, summarizes data from Table 1-A of the IISS Military Balance 1975-1976:

TABLE I

1975 Postures (IISS MIL BALANCE)

	Strategic Nuclear Delivery Vehicles (SNDV)	
	US	USSR
MLBM		299
ICBM(s)	1054	1318
Bombers	432	135
SLBM	656	724
Total	2142	2477

The capabilities of these weapons measured in number of weapons and EMT are summarized in Table II. This required some external sources and assumptions to fill in gaps in the data, No informed judgment was used - the first number discovered in a literature search was adopted. An arbitrary 80% of inventory bombers and SLBM were counted as on-line and loaded.

TABLE II

1975 Postures: Force Measures by Components

	WEAPONS		EMT	
	US	USSR	US	USSR
MLBM		300		1400
ICBM(s)	2100	1600	1200	2000
Bombers	2500	300	2100	300
SLBM	3400	600	600	700
	8000	2800	3900	4400

Table II illustrates two significant measures of capability discussed elsewhere. Weapon numbers are a reasonable measure of

military coverage, while EMT is a good indicator of target value for counterforce attack. The U.S. weapons advantage illustrated has been used publicly as a claim of U.S. superiority and probably influences Soviet eagerness to get on with MIRV deployment. Relative emphasis on basing modes is also illustrated. By either measure, the Soviets have over two-thirds of their capability in ICBM, the U.S. has over two-thirds in bombers and SLBM.

Table III provides the basis for assessing these measures as elements of the military balance: Targetable EMT or weapons at risk comprise an incentive to acquire target-kill capability and/or escalate to a disarming attack; conditionally targetable, an incentive to strike without warning;and non-targetable, the component that provides capability for flexible response if the other components do not comprise too strong an escalatory incentive. In this table, values are given in hundreds to deemphasize small differences and accentuate the major ones. An arbitrary division of on-line bombers and SLBM into alert and non-alert categories is used. Both sides are credited with 40% of bombers and 2/3 of deployed SLBM on alert or at sea,1/ with the remainder capable of being generated on strategic warning. This was used in full awareness of its inapplicability to the USSR in default of suitable estimates. None could be found in materials at hand. It is adequate for illustrative purposes.

Currently, as of 1975, the lack of hard target kill potential on both sides limits counterforce vulnerability to the conditionally targetable component. This is shown somewhat larger for the U.S. than the Soviets because of relative emphasis on EMT in bombers and weapons in POSEIDON. This, however, represents relative advance in U.S. precautions for the advent of capability against ICBM.

As an indicator of potential trends, Table IV illustrates the extrapolation of the current programs of both sides to one possible implementation2/ of the terms of the Vladivostok accord.

1/ Quanbeck, op cit p. 34 and, Polmar op cit p. 103 note 42.

2/ The U.S. is postulated to deploy the 240 B-1 which have been proposed and to deploy enough TRIDENT to fill out the quota of 1320 MIRVs. B-52s are assumed to phase down to stay within the 2400 overall SNDV limit. The Soviets are postulated to fill their 300 MLBM silos with the MIRVed SS-18, to make up the remainder of their 1320 quota with SS-19 and to fulfill their interim agreement quota of 950 SLBM. Soviet ICBM are assumed phased down as necessary to stay within the 2400 limit. Number of weapons per booster is as in the IISS Table, with 6 and 8 MIRV in the SS-19/18 and TRIDENT assumed like POSEIDON. The substitution of B-1 for about half of the B-52s is assumed (arbitrarily) to add 50% to the total bomber loading and raise average alert rate of the B-1/B-52 force to 50%.

TABLE III

1975 Postures (IISS MIL BALANCE)

	EMT PER TGT	SNDV US	SNDV USSR	WEAPONS US	WEAPONS USSR	EMT US	EMT USSR
Total		2142	2477	8000	2800	3900	4400
				Elements in the Military Balance (Hundreds)			
Targetable							
MLBM	30-10		3		3		14
ICBM	1-2	11	13	21	16	12	20
<u>Total Targetable</u>		11(.49)	16(.65)	21(.26)	19(.68)	12(.31)	34(.77)
Conditionally Targetable (non-alert, in port)							
Bombers	20-50	3	1	15	2	13	2
SLBM	20-50	2	2	11	2	2	2
<u>Surprise Vulnerability Increment</u>		5(.22)	3(.13)	26(.33)	4(.14)	14(.37)	4(.09)
Non-Targetable (Alert/at sea)							
Bombers		2	0	10	1	8	1
SLBM		4	4	23	4	4	5
<u>Non Targetable</u>		6(.28)	5(.22)	33(.41)	5(.19)	12(.32)	6(.13)

In this example, the U.S. fills out its MIRV quota with TRIDENT while the Soviets use silo-based SS-18 and 19. EMT are not calculated since data on yields of the new systems are lacking.

TABLE IV

Postulated Force Postures Augmented to 2400 (1320 MIRV)

	SNDV		WEAPONS	
	US	USSR	US	USSR
MLBM		300		2300
ICBM(s)	1054	1015	2100	6400
Bombers	416	135	3800	300
SLBM	930	950	6300	800
	2400	2400	12200	9800

Table V illustrates the breakdown of this potential posture into military categories. The U.S. with almost as many weapons in non-targetable or conditionally targetable modes as the Soviets have targetable is in a much more flexible position than the Soviet force. The U.S. could ride out even a 100 percent disarming attack against ICBM and have 50-80% of its weapons survive.

If the Soviets fail to achieve all-out damage limitation and the U.S. balances Soviet ICBM accuracy developments with accuracies in non-targetable systems (SLBM, cruise missiles, bombers) the Soviets have only fire-on-warning as an alternative to an all-out attack, either first or second strike, with the U.S. forces then holding the initiative. Fire-on-warning is, to be sure, a valuable threat to deter counterforce attack. A force which relies on this for survival foregoes flexibility and disarms itself even if attacked poorly. While the damage it does can be large, this is no advantage if other available forces are sufficient. Heavy damage in an automatic response can be a disadvantage if there might otherwise have been hope of terminating short of the all-out countervalue exchange.

All of the above is conditional on the two premises noted: absence of a full Soviet damage limitation posture and non-targetable U.S. counterforce capability. The following possibilities could turn the situation to Soviet advantage:

- A Soviet extended damage limiting capability complementing counterforce attack.

  -- ABM and/or preemptive ASW to circumvent the non-targetabilitity of SSBN

-- Impenetrable bomber defense and/or a sneak attack to get alert bombers before launch.

-- Effective civil defense.

- A U.S. posture that limited its hard target capability to targetable systems. Since Soviet counterforce when attainable is assumed constrained by fratricide, only 1000-2000 weapons will be required, 10-20% of the total. If destruction of 1/3 of U.S. weapons with 1/10 to 1/5 of theirs also removed the U.S. second-strike counterforce threat to the other 80-90% of Soviet ICBM it might seem an attractive option in a crisis.

TABLE V

	EMT PER TGT	Augmented to 2400/1320 SNDV (Hundreds)		WEAPONS (Hundreds)	
		US	USSR	US	USSR
Total		2400	2400	12,200	9800
Targetable					
MLBM	3-10		3		23
ICBM	1-2	10	10	21	64
Total Targetable		10(.44)	13(.55)	21(.17)	87(.89)
Conditionally Targetable					
Bombers	20-50	2	1	19	2
SLBM	20-50	3	3	21	3
Surprise Vulnerability		5(.22)	4(.17)	40(.33)	4(.05)
Non-Targetable					
Bombers		2	1	19	1
SLBM		6	6	42	5
Non-Targetable Total		8(.35)	7(.29)	61(.50)	7(.07)

TAB A TO APPENDIX B

COMPARISON OF
US-SOVIET STRATEGIC SUBMARINES

- o MISSIONS/EMPLOYMENT
- o PHYSICAL COMPARISON
- o ORDER OF BATTLE
- o MISSILES
- o NAVIGATION
- o COMMAND, CONTROL AND COMMUNICATIONS
- o SURVIVABILITY
- o NEXT GENERATION SUBMARINE
- o NEXT GENERATION MISSILE
- o PRODUCTION
- o STRENGTHS & WEAKNESSES

MISSION/EMPLOYMENT

U.S.	USSR
o STRATEGIC DETERRENCE/ATTACK	o STRATEGIC DETERRENCE/ATTACK
o CONTINUOUS PATROL CYCLE (~50%) (2/3 OF THOSE DEPLOYED)	o VERY LIMITED PEACETIME DEPLOYMENTS
o HIGH IN-PORT READINESS	o HIGH IN-PORT READINESS

PHYSICAL COMPARISON

US	USSR
o 425 L.O.A. 32 FT BEAM	426 FT L.O.A. 38 FT BEAM
o SUBMERGED DISPLACEMENT: 8250	
o PROPULSION: SINGLE SHAFT	TWIN SHAFT
o DEPTH: >400 FT	> 400 FT
o SPEED >20 KT	25 KT
o MISSILES 16	16
o TORPEDO TUBES 4	6

ORDER OF BATTLE *

U.S.

o INVENTORY	SSBN	SLBM	WEA
° POLARIS A3	16	256	256
° POSEIDON C3	25	400	4000
TOTAL	41	656	4256

LOCATION	SSBN
° HOLY LOCH	10
° ROTA	10
° GUAM	7
° CHARLESTON	5
° OVERHAUL/ SHAKEDOWN	9
TOTAL	41

USSR

INVENTORY	SSBN	SLBM	WEA
YANKEE	34	544	544
DELTA	13	156	156
HOTEL	8	24	24
GOLF	20	60	60
TOTAL	75	791	791

LOCATION

NORTHERN FLEET - 2/3

PACIFIC FLEET - 1/3

* SSBN/SLBM/WEAPONS FROM IISS "STRATEGIC BALANCE" 1975-76 PP 5-8

MISSILES

POLARIS A3	POSEIDON C3	SS-N-6	SS-N-8
o TWO STAGE SOLID	TWO STAGE SOLID	o SINGLE STAGE LIQUID	TWO STAGE LIQUID
o 2500 NM	2500 NM	o 1300 - 1600 NM	4200 NM
o 3 MRV	UP TO 14 MIRV	o SINGLE & MRV	SINGLE
		o WARHEAD YIELD MT RANGE	MT RANGE

NAVIGATION

U.S.	USSR
o REDUNDANT SINS	o SINS
o NAVSAT (TRANSIT)	o NAVSAT
o LORAN C	o LORAN C OMEGA, AND SOVIET EQUIVALENTS
o BOTTOM CONTOUR	o BOTTOM CONTOUR

COMMAND, CONTROL, AND COMMUNICATIONS

U.S.	USSR
o VLF, LF, HF BACKUP	o VLF, HF BACKUP
o SECURE, REDUNDANT, LIMITED SURVIVABILITY: ° TACAMO ° FREQUENT TESTS AND DRILLS	o SECURE, REDUNDANT, MORE SURVIVABLE
o PRIORITIES: ° REMAIN UNDETECTED ° MAINTAIN COMMS RECEPTION	o PRIORITIES: ° DIFFERENT FROM U.S.

COMMAND, CONTROL, AND COMMUNICATIONS

U.S.	USSR
o VLF, LF, HF BACKUP	o VLF, HF BACKUP
o SECURE, REDUNDANT, LIMITED SURVIVABILITY:	o SECURE, REDUNDANT, MORE SURVIVABLE
° TACAMO	
° FREQUENT TESTS AND DRILLS	
o PRIORITIES:	o PRIORITIES:
° REMAIN UNDETECTED	° DIFFERENT FROM U.S.
° MAINTAIN COMMS RECEPTION	

SURVIVABILITY

U.S.	USSR
o QUIETING (BELOW AMBIENT SEA NOISE)	o NO APPARENT EMPHASIS ON QUIETING
o SENSORS (FIRST DETECTION)	o PASSIVE SONAR BELIEVED TO LAG U.S.
o RANGE RESTRICTED	o YANKEE-RANGE RESTRICTED DELTA-NOT RANGE RESTRICTED
o SSBN SECURITY PROGRAM	

NEXT GENERATION SUBBMARINE

U.S.	USSR	
TRIDENT	DELTA	FOLLOW-ON
o 2 EACH 3 YRS		
o 24 MISSILES	o 16 MISSILES	o 16 MILLES +
o >20 KT		
o 10C 1979		o FASTER
o >400 FT DEPTH	o IOC 1975	
o QUIETER		
o IMPROVED SONAR		

NEXT GENERATION MISSILE

U.S.	U.S.	USSR	USSR
TRIDENT I (C-4)	TRIDENT II		
o IOC 1979 o 4,000 NM FULL PAYLOAD o THREE-STAGE SOLID o POSEIDON-LIKE PAYLOAD o OPTIONS FOR MaRV	o IOC MID '80s o GREATER RANGE PAYLOAD COMBINATION o IMPROVED ACCURACY o R/V OPTIONS (INCL. MaRV)	o 2,000 NM o MIRVs	o 4,000 NM o MIRVs

PRODUCTION

U.S.	USSR
o FORCE CONSTRUCTED 1959 - 1967 (160 POLARIS TUBES, 496 POSEIDON TUBES)	o BUILDING 3 CLASSES OF SSBNs (791 TUBES TODAY)
o CAPACITY FOR 2 TRIDENTS PER YR (ONE SHIPYARD)	
o BUILDING 3 EVERY TWO YEARS	
o OVERHAUL POSEIDON EVERY SIX TO NINE YEARS	o 62 HULLS SOON AFTER SALT I EXPIRED

STRENGTHS AND WEAKNESSES

U.S.	USSR
o HIGH PERCENTAGE ON-STATION WITH HIGH IN-PORT READINESS	o LOW PERCENTAGE ON STATION BUT HIGH IN-PORT READINESS
o HIGH SURVIVABILITY	o LESS SURVIVABLE
° FEW IN-PORT	° MORE IN-PORT
° QUIET/SONAR	° NOISY/POOR SONAR
	° RELY ON STRATEGIC WARNING
o NON-SURVIVABLE C^3	o MORE SURVIVABLE C^3
o LOW PRODUCTION CAPABILITY	o DESIGN/PRODUCTION MOMENTUM
o MISSILE RANGE LIMITED	o DELTA CAN STAY IN HOME WATERS (NOT MISSILE RANGE LIMITED)
o GROWTH LIMITED	o VERY LARGE SSBN FORCE

APPENDIX C

STABILITY OVER TIME. REDUNDANCY, DIVERSITY

- Definitions:
  - Diversity is the number of alternative systems each of which is sufficiently different from the others to avoid vulnerability to the same countermeasure.
  - Assurance afforded by diversity is not objectively quantifiable, but changes, whether assurance is increasing or diminishing, can be assessed.
- Comment:
  - Military history abounds with instances of strategic obsolescence as new weapons or tactics dominate situations where the old are found wanting.
  - There are three types of such transition:
    - New tactics or modes of warfare that transcend.
    - Breakthroughs in firepower that supersede or outrange.
    - Countermeasures that defeat specific systems.
  - There is ample indication that no military measure or system, however superior at a given juncture, is immune from eventual obsolescence.
  - Whether or not a military power becomes a victim of such a development depends in large part on the resistance or acceptance of innovation in its military forces and strategies.
  - One cogent measure of this characteristic of the military force is the actual diversity maintained among systems in the posture. Tab A to Appendix C displays one analytical procedure that attempts to trade diversity off against capability to maximize assurance with respect to one objective of a strategic mix.
  - Another measure is the flexibility afforded by the posture and the strategic policy to adapt strategy to circumstances as they change (see Annex A-5).

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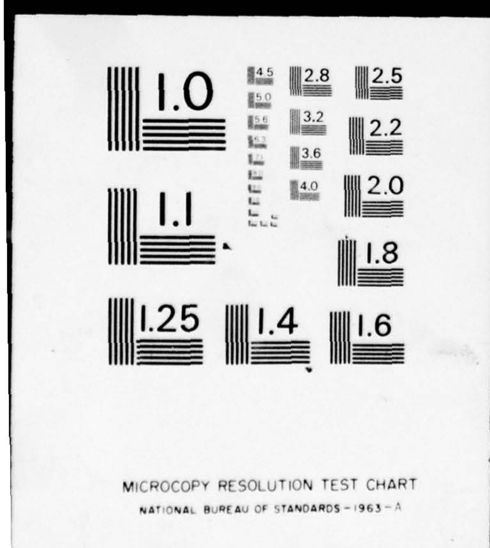
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

° History:

- The availability of heavy bombers dictate the early deployments of nuclear bombs later augmented modestly by heavy carrier-based aircraft and cruise missiles.

- Early ballistic missiles also carried large throwweights.

- It was not until the late 50s when technology provided weapons both in numbers and sizes small enough for carriage on a variety of systems that the challenge to explore diverse basing schemes was met.

- During the late 50s and early 60s a wide variety of schemes were proposed and some carried into various stages of development and deployment - Airlaunched (SKYBOLT) surface ship (MINUTEMAN and POLARIS, Multilateral Force) barges (ICBM) railroad (MM).

- In the mid to late 60s most alternatives were discontinued under pressure of highly competitive cost/effectiveness analyses favoring the selection of one "best" system and discrediting "duplication."

- The "well hedged mix" narrowed down in the late 60s to silo based MINUTEMAN, bombers and SLBM, with candidates such as a surface ship (BMS), land mobile ICBM and cruise missiles (SCAD/ALCM/SLCM) held at very low levels of acceptance.

- In the late 60s with the advent of the threat to MINUTEMAN as a publicly declared issue, the concept of the TRIAD was introduced. This had the effect of inhibiting discussion not only of trade-offs between central systems but also of new diverse elements.

° <u>Applicability to the Strategic Balance and SLBM Contributions</u>

- The appropriate measure of diversity and of relative vulnerability to surprise is the following.

  -- An accounting measuring how many differences among systems exist that are distinct enough to imply invulnerability all to the same counter; ballistic missiles - cruise missiles - bombers; silos - land mobile - air mobile - sea mobile - submarine - transportable/concealable; diverse models within types; nuclear-non nuclear submarine, off-road-rail mobile; etc.

  -- A series of proportions indicating the fraction of the mix not relying on any single type of system or assumption as to vulnerability.

TAB A TO APPENDIX C

1972

Subj: Risk Model For Strategic Force Mix Assessment

Encl: (1) Draft Risk Model for Strategic Force Mix Assessment
(2) Quantitative Examples

1. (U) The enclosures are submitted as of possible interest. Its intent is to provide the minimum elaboration on the conventional rationale of the "TRIAD" that will permit consideration of measures that preserve the benefits of a mix of independent systems in the face of changing circumstances. Lack of such elaboration has permitted the conclusion that any tampering with the present mix would destroy the benefits of redundancy and synergism. The model described in the enclosure, using methods of elementary mathematical statistics, is at least as valid and far more useful than the current TRIAD rationale.

2. (U) The draft is rough and unrefined, there may be arithmetical errors and there certainly will be disagreement with the parameters arbitarily selected to illustrate. It is hoped better inputs and further work may make it actually useful.

3. (U) The model permits assessment using expected capability and capability under greater than expected threats, two measures which are assessed frequently enough that more or less agreed values can be documented. It manipulates these numbers as if they were the mean and a multiple of the standard deviation in a standard probability distribution. The corresponding parameters of the total force mix can thus be calculated.

4. (U) The first round of trial calculations (in enclosure (2)) supports the following tentative observations:

- Even using optimistic survivability estimates, MINUTEMAN is relatively oversubscribed in the context of a SALT ceiling: Almost any reasonable substitute for some fraction of the 1000 ICBM including one having exactly the same characteristics (except not threatened by the same threats) improves the mix.

- Within a SALT ceiling equal to the present US force level, substitution of more effective systems would permit very large increases both in expected force capability and in net assured delivery capability. Both reductions and or increased warfighting capability are feasible so long as freedom to mix and to improve is preserved.

- We may not have enough independent candidate systems to fulfill this potential. Unless we intend to seek substantial reductions in SALT, the OSD guidance *in re* diversification ought to be taken seriously.

Draft Model for Strategic Force Mix Assessment

1. Description:

Consider a strategic force component, one of several in the overall mix:

The n delivery vehicles in its inventory are expected, for planning purposes to deliver a total of ne equivalent megatons on target. The net expectation, e is the product of yield, and expected degradations from reliability, base loss, direct and virtual (defense suppression) losses to defense, etc.

Another characteristic of the component is the additional degradation that might be incurred if the worst feasible threat were to eventuate. If the capability of this pessimistically degraded force is $ne(1-k)$ we can define a parameter, $\sqrt{v} = ke$

The premise of the model is that the mix as a whole will have an expected delivery capability, $E = \sum_i n_i e_i$ and that against the worst combination of threats, its assured capability would be $A = \sum_i n_i e_i - \sqrt{\sum_i n_i^2 v_i}$

This formulation presupposes that the greater than expected degradation of each system is independent of that suffered by the others in the mix. Since this

Enclosure (1) to Memo

is unlikely to be the case, we incorporate a further consideration and restate the assured capability

$$A = \sum_i n_i e_i - \sqrt{\sum_i n_i^2 v_i + 2\sum_{ij} Cov(i,j)}$$

In this expression the term $Cov(i,j)$ expresses the relationship between the degradation of the i^{th} and j^{th} systems. For example, it could be negative in case of bombers and ICBM to express "synergism."

2. <u>Validity:</u>

If the expectations and worse-than expected probability distributions were Gaussian, the model is exact - the assured level, A, for the force as a whole would correspond to a level of confidence represented by that entailed in discounting the greater than expected threats to individual systems. Since gaussian distributions are unlikely it can only be an indicator. Moreover, if one wishes to manipulate the force levels, n appreciably the model is too naive to account for the (frequent) dependence of effectiveness per vehicle, e on the numbers, saturation, for example.

These limitations indicate caution. One application that is believed to be valid is to test whether there may be benefits to assurance from changing the composition of the mix. If, using accepted parameters, benefits are indicated, and if parameters reevaluated presupposing the changed mix do not reverse this conclusion, there should be a reasonable presumption that the change gave at least the smaller of the two indicated improvements.

J. Application to freedom to mix: replacement of one system by another:

After replacement of n vehicles with a new system having effectiveness e and risk parameter v out of a total of n_1 of another component (with parameters e_1, v_1) the assured effectiveness of the new mix will be $A = E_0 + (e - e_1)n - \sqrt{(v + v_1)n^2 - 2n_1 v_1 n + V_0}$

Where E_0 and V_0 are the corresponding overall effectiveness and greater than expected loss of the original mix. (The iterative process noted in the previous paragraph permits correlation to be left out if all we wish is a go-no-go answer; it will be left out in this example for simplicity of exposition.)

By manipulating the derivative with respect to n we can find an expression for a provisional optimum mix n_{opt} which (again repeating our caveat) deserves interpretation as a good candidate place to stop and reevaluate whether assumptions have been significantly changed. The value at this point may also be a useful indicator of whether there is enough potential in the change to justify beginning the process at all. This provisional optimum level has the value

$$n_{opt} = \frac{n_1 v_1}{v + v_1}\left[1 + (e - e_1)\sqrt{\frac{\frac{(v + v_1)V_0}{n^2 v_1^2} - 1}{v + v_1 - (e - e_1)^2}}\right]$$

Inspection of this expression permits some interesting generalizations:

- The optimum number displaced is by no means necessarily 100% (as is the usual conclusion from simple expected value models).

- The number increases with diminished variability of the new system, with increased effectiveness, and with increased number of the old system already deployed.

- Even a less effective system is a candidate if the loss, $\ell - \ell_1$ is not too serious.

- The weight given to effectiveness, i.e. whether all should be replaced by a more effective system or none by a less effective one increases with increased overall mix variability and can be dominated by the question whether $(\ell - \ell_1)^2 < v + v_1$

At some point before these become equal, the optimum mix is a complete replacement or none at all; depending on whether ℓ is larger or smaller than ℓ_1.

4. Extension:

A somewhat more generalized model can be formulated on the same basis as that above to test the sensitivity of the mix to specific characteristics that different elements in the mix may have in common, and which may invite countermeasures. The use by two separate missile systems of a particular penetration aid, weapon design, etc. or the use by all sea-based systems of nuclear propulsion are examples.

Instead of our estimate, v, of the greater than expected loss to a specific element in the mix, we define a parameter, ω, as the corresponding loss to systems relying upon the characteristic, c. Instead of our measure, n, of the number of vehicles we substitute a term $\frac{\partial E}{\partial c}$ which evaluates the contribution to the mix as a whole of all systems having the characteristic.

The overall mix will have a greater than expected loss parameter which can be evaluated as $\gamma = \sum_i \left(\frac{\partial E}{dc_i}\right)^2 \omega_i$ for example where the characteristic is unique to a component with n units, $\frac{\partial E}{dc} = n$ and if all characteristics that lead to possible threats are accounted for, the variability v will equal the sum of their parameters, ω, and $\sum_j \left(\frac{dE}{dc_j}\right)^2 \omega_j$ for the characteristics of this component will equal $n^2 v$, which is the same term used in the more special application above.

By analogy, also, to the treatment, above, of correlation between greater than expected threats, a covariance can be accounted for.

The great difficulty in such an extension is evaluating parameters acceptably, since unlike the greater than expected threats the literature of current assessment is not couched in appropriate terms. There may, however, be some useful applications testing sensitivity where gross approximations are adequate.

Quantitative Examples

1. Table 1 shows tentative values of parameters for the present strategic mix and several candidates for replacement. The values are selected arbitrarily to correspond with a time in the future when the expected contribution of the three elements in the present TRIAD would be equal, and postulates plausible further degradations in prelaunch survival and penetration capability. Tab A illustrates details of how they were derived. Using these inputs the following typical calculations can be made.

- The parameter for the force as it stands are

POL/POS + MM + Bombers

$$E = 6.5 \times .38 + 10 \times .25 + 4.5 \times .56 = 7.5$$

$$V = 6.5^2 \times .08 + 10^2 \times .04 + 4.5^2 \times .27 = 13.1$$

$$A = E - \sqrt{V} = 7.5 - 3.6 = 3.9$$

That is to say the mix is currently equally balanced among the three components and the assured value, as calculated, is almost 400 equivalent megatons. Table 2 illustrates this and other similar calculations using samples including optimum substitutions of various kinds.

- A test can be made of the existing missile mix by assuming 1650 MINUTEMAN or 1650 POLARIS/POSEIDON and finding the optimum displacement of one by the other (assuming bombers held constant). The optimum displacement calculation yields a mix of 980 POLARIS/POSEIDON and 670 MINUTEMAN. As shown, this is only

a slight improvement over the existing mix but is significantly better than a "DYAD" leaving one or the other force out altogether. An excursion assuming correlation* in the form of joint POSEIDON/MINUTEMAN vulnerability to ABM breakthrough led to an even greater share of the mix allocated to POSEIDON.

- A test (5a) was made of substitution of TRIDENT for MINUTEMAN. In this case the increased net effectiveness so dominated the calculation that 100% replacement was indicated. Since this calculation obviously violates the data (e.g. synergism, etc.) it is included only for interest.

- A force of 250 TRIDENTS (about 10 boats) has the expected value of any one of our present force components and seemed to be a good place to stop and look for alternatives. This force (Number 5b in Table 2) is a significant improvement over the present mix offering one quarter more expected value and half again more assured value. The latter would be reduced on reassessment** to account for correlation between POSEIDON and TRIDENT threats if the threat of a breakthrough is weighed more heavily than the dilution of the threat to POSEIDON by TRIDENT.

* $Cov(Pos/MM) = \rho\, n_{pos}\, n_{mm}\, v_{pos}\, v_{mm}$ $\rho = .25$ in this example.

** A check to see whether reduced MM survivability due to larger attack per silo would be significant reduced the net expectation, and ...

- An exchange of B-1 for MINUTEMAN in the presence of TRIDENT (entry 6a) did not dominate and fully replace as did TRIDENT. It still led to a much larger than programmed number of B-1 and 6(b) assesses a 200 B-1 substitution.

2. At this iteration two tentative conclusions become evident (pending checks to validate the inputs and determine whether correlations or other parameter dependencies may interfere).

- Minuteman is a tempting candidate for replacement by other systems - whatever we do seems to be an improvement.

- In TRIDENT and B-1 we have systems that are so effective that failing very significant reductions in SALT we must look elsewhere to fill up our quota without overcommitment or extravagance.

3. (U) Two tentative excursions are tried in items 7 and 8 to meet this dilemma:

- A smaller bomber than B-1 was arbitrarily postulated to be identical in every characteristic except 40% as much payload and 40% less of this required for defense suppression (because smaller target and more bombers). An optimum substitution of these for MINUTEMAN gave about the same number as B-1, not quite as much expected value as this extravagant B-1 force, but a

better force than that limited to 200 B-1.

- Another arbitrary system, System X, was postulated. this candidate was given all the characteristics of MINUTEMAN except only that it was assumed independent: a new force not subject to the same threats. A sample force mix utilizing somewhat fewer bombers than item 7 and thus having less expected delivery capability exhibits more assured capability owing to the increased redundancy.

4. This excursion illustrates that even a system with exceedingly poor cost/effectiveness credentials may in some cases add to the value of an overall mix.

Table 1

	POL/POS	MM	B-52	TRIDENT	B-1	
n (hundreds)	5.5	10	4.5			
e	.38	.25	.56	1.0	.72	.46
$\sqrt{v}$	.28	.21	.52	.60	.63	.40
v	.08	.04	.27	.36	.40	.16

Table 1 to Enclosure (2) to

Table 2
Sample Mix Calculations

Operation	Force Mix						Evaluation
	POL/POS	MM	B-52	TRID	B-1	Small	$E - \sqrt{V} = A$
1. Present Mix	6.5	10	4.5	0	0	0	7.5 - 3.6 = 3.9
2. Land Based Only	0	16.5	4.5				6.6 - 4.0 = 2.6
3. Sea & Bombers	16.5	0	4.5				8.8 - 5.2 = 3.4
4. Opt Mix MM/POS	9.8	6.7	4.5				7.9 - 3.9 = 4.0
5(a) 1 + all TRIDENTS for MM	(6.5	0	4.5	7.5)			15.0 - 6.5 - 8.5
5(b) 1 + 2.5 TRIDENTS for MM	6.5	7.5	4.5	2.5			9.4 - 3.6 = 5.8
6(a) 1 + TRID + Opt B-1	6.5	5.9	0	2.5	6.1		10.9 - 4.7 = 7.2
6(b) 1 + TRID + B-1 for B-52	6.5	10	0	2.5	2.0		8.9 - 3.3 = 5.6
7. 6 + Small Bomber for MM	6.5	5.9	0	2.5	0	6.1	9.3 - 3.6 = 5.7
8. 7 except add System X	6.5	3.5 + 3.5	0	2.5	0	5	9.1 - 3.2 = 5.9

TAB A

Tentative Parameters for Force Mix Calculations

	POL/POS	MM	B-52/111	TRIDENT	B-1	Small Bomber
n (hundreds)	6.5	10	4.5			
EMT						
Alert						
P(Survive if alert)	1.0	.4	1.0	1.0	1.0	1.0
Reliability						
P(Pene if arrive)	1.0	1.0	.7	1.0	.9	.9
P(Wea not for defense suppression)						
e	.38	.25	.56	1.0	.72	.46
ne	2.5	2.5	2.5			

Worst Case Values

P(Survive if alert)	.5	.1	.4	.8	.6	.6
P(Pene if arrive)	.5	.5	.1	.5	.2	.2
k	.75	.875	.94	.6	.87	.87
$ke = \sqrt{v}$	.28	.21	.52	.60	.63	.40
v	.08	.04	.27	.36	.40	.16

TNW AND THE STRATEGIC BALANCE

by

Colonel Stanley D. Fair

In the European military balance, the Warsaw Pact has enjoyed an advantage over NATO in conventional force levels since the inception of the Warsaw Treaty Organization. NATO has relied on nuclear weapons to offset this advantage: first, in the strategy of massive retaliation and later, within the strategy of flexible response. In the strategy of massive retaliation, tactical nuclear weapons (TNW) were considered to be an integral part of the total nuclear power available to the Alliance, with no deterrent or defense role independent of US strategic nuclear forces. Within the strategy of flexible response and under the conditions of strategic parity, the deterrent and defense responsibilities of TNW have increased in the theater while the role of US strategic nuclear forces in the defense of Europe has been deemphasized. These doctrinal changes have tended to create the impression that TNW and US strategic nuclear forces are separate and almost unrelated capabilities: the former being considered only as a factor in the European military equation, and the latter being limited to comparisons of US/USSR strategic nuclear forces.

The thesis of this paper is that TNW have an impact on the overall strategic balance because of deterrent interrelationships and potential defense interactions among NATO's theater nuclear and conventional forces and US strategic nuclear forces. Despite certain doctrinal changes, US

policy still does not preclude the first use of TNW by NATO's theater nuclear forces in response to an overwhelming conventional attack by the Warsaw Pact. This threat helps to deter large-scale conventional aggression, and if NATO should need to carry out the threat, the TNW capability, backed up by highly-survivable second-strike nuclear capabilities in Europe and the United States, should deter both a preemptive nuclear strike and a nuclear response by the Warsaw Pact. TNW lend stability to the strategic balance in peacetime, and if they are used early in war to compensate for deficiencies in NATO's conventional defense capabilities, TNW have the potential to tip the strategic balance in favor of the West.

EVOLUTION OF DOCTRINE

The Soviet Union reacted to the deployment of US tactical nuclear weapons to Europe by concentrating its efforts on development of missiles to support an opposing theater nuclear capability. The success of the Soviet Union in space technology in the late 1950's and the evidence of sizable Soviet theater nuclear forces opposite Western Europe in the early 1960's prompted the US officials to advocate that NATO adopt the strategy of flexible response. Under this new strategy, formally adopted by NATO in 1967, the threat of an immediate and exclusive nuclear response to aggression was to be replaced by the doctrine of graduated deterrence: response to aggression would be in the form and at the level appropriate for the situation. TNW would still be used to support strategic forces in general war, but the threat represented by Soviet tactical nuclear capabilities

required that NATO's theater nuclear forces be assigned additional deterrence and defense roles, independent of US strategic nuclear forces. The new strategy of flexible response would also increase the deterrent and defense responsibilities of NATO's conventional forces.

According to Harlan Cleveland, former US Ambassador to NATO, the strategy of flexible response confronted "the enemy with a credible threat of escalation in response to any type of aggression below the level of a major nuclear attack."[1] Thus, the new strategy established a doctrinal relationship between that element of military power representing a direct response to the type of aggression selected by the enemy and that element of military power constituting an escalatory response. NATO's conventional forces shared the deterrence of conventional aggression with NATO's theater nuclear forces; NATO's theater nuclear forces were linked to US strategic nuclear forces to deter the enemy's use of nuclear weapons in Europe. If deterrence of conventional aggression failed, NATO's conventional forces were required to conduct a resolute defense rather than merely serve in a tripwire role. If the efforts of NATO's conventional forces proved to be inadequate, NATO's theater nuclear forces were to carry out the threat of escalation. If the enemy responded with nuclear weapons or initiated their use, NATO's theater nuclear forces were to defend, and NATO leaders were to threaten general war, in which, at that time, the Soviet Union would have been at a disadvantage.

Meanwhile, the Soviet Union was developing a strategic nuclear capability, and France, as a result of disagreement with her NATO allies over the strategy of flexible response, withdrew from military participation in the Alliance in 1966 and began also to develop an independent strategic nuclear capability. By 1969 it was apparent that the Soviet Union was approaching rough parity in strategic forces with the United States and that concepts for the use of TNW which relied upon US strategic superiority would lack the degree of credibility they had enjoyed previously. President Nixon reacted to this fundamental change in the strategic balance by questioning the single option for the use of US strategic forces under the concept of assured destruction.[2] He recognized also that the growth of Soviet strategic forces had implications for the "relative role of strategic nuclear forces, conventional forces, and tactical nuclear weapons."[3]

The effect of strategic parity on the deterrent and defense roles for NATO's TNW became evident in April 1975 in a report to Congress by the Secretary of Defense on The Theater Nuclear Force Posture in Europe. This report acknowledged that "the threat of mutual annihilation limits the range of hostile actions which can be deterred by strategic forces and places more emphasis on the deterrent roles of theater nuclear and conventional forces."[4] Although US strategic nuclear forces would continue to be coupled to the deterrence of attacks on Europe, strategic parity would require that NATO's theater nuclear and conventional forces shoulder more of the deterrence burden than in the past. Deterrence for NATO could no longer be based solely on the threat of escalation but must rely also on the military capabilities

within the theater which a prudent enemy would perceive as sufficient to deny him his expectation of success. Because of strategic parity, the doctrinal emphasis within NATO's strategy of flexible response would be on direct defense rather than on deliberate escalation.

The report on The Theater Nuclear Force Posture in Europe explained also that NATO relies on a mutually supporting mix of conventional, theater nuclear, and strategic forces for deterrence and defense. The conventional forces of the NATO Triad are to deter and defend against conventional aggression. Theater nuclear forces deter and defend against theater nuclear attacks; help deter and, if necessary defend against conventional attack; and help deter conflict escalation. Strategic forces deter and defend in general war, deter conflict escalation, and reinforce theater nuclear forces if needed. This reinforcement role could involve the execution of limited strategic options by US strategic forces in the defense of Europe. These limited strategic options were described by the US Secreatry of Defense in March 1974 as part of the doctrine of flexible strategic response and as "measured responses to aggression which bear some relations to the provocation, have prospects of terminating hostilities before general nuclear war breaks out, and leave some possibility for restoring deterrence."[5]

THE STRATEGIC BALANCE

In the overall strategic balance, a simple numerical comparison of capabilities will show an advantage for the Warsaw Pact in conventional forces, an advantage for NATO in TNW, and essential equivalence in strategic

nuclear systems. This type of presentation is misleading because the large number of TNW deployed in Europe were accumulated to support the earlier strategy of massive retaliation. The objective for using TNW during that period was to destroy or defeat the invading Warsaw Pact forces and to help restore the territorial integrity of the Alliance. Within the strategy of flexible response and under the conditions of strategic parity, the objective for using TNW is "the termination of war on terms acceptable to the United States and its allies at the lowest feasible level of conflict."[6] The current objective reflects an attempt not only to avoid escalation but also to control the collateral effects of using nuclear weapons in Europe.

This exercise of restraint is exhibited also in the concepts for the use of TNW. If NATO should initiate the use of TNW, "first use should be clearly limited and defensive in nature, so as to reduce the risk of escalation. However, the attack should be delivered with sufficient shock and decisiveness to forcibly change the perceptions of WP leaders and create a situation conducive to negotiations."[7] If the Warsaw Pact should be the first to use nuclear weapons or respond to NATO's restrained first use, "efforts would be made to control escalation . . . by a combination of clearly perceivable limits on the NATO nuclear response and the threat of more extensive strikes with theater and strategic forces if the WP chooses to escalate."[8] This policy guidance on first and retaliatory uses of TNW by NATO forces indicates clearly that NATO's numerical advantage over the

Warsaw Pact lies more in the deterrent effect of withheld capabilities than in the operational effect of planned uses.

This is not to say that NATO leaders are ignoring the realities of strategic parity. The concepts for first and retaliatory uses of TNW by NATO do not rely on US strategic nuclear superiority or depend solely upon the threat of escalation. Rather, current concepts for the use of TNW base their credibility primarily on highly-survivable second-strike nuclear capabilities located in Europe and the United States. These second-strike capabilities are currently limited to strategic nuclear systems, but efforts are under way to reduce the vulnerability of NATO's dual-capable systems to conventional and nuclear attack. NATO's "theater nuclear forces and their essential support (e.g., warheads, delivery systems, intelligence, command, control and communications (C^3), and logistics) must be sufficiently survivable to have credible retaliatory capability."[9]

A skeptic might doubt that US strategic nuclear forces are still so closely tied to NATO's theater nuclear forces and consider NATO's in-theater strategic nuclear capability as a surrogate for US strategic nuclear forces. Nevertheless, the provision for limited strategic options, which could be executed in situations short of general nuclear war to reinforce NATO's theater nuclear forces, couples TNW and US strategic nuclear forces almost as close as they were under the strategy of massive retaliation. The new relationship merely reverses their respective roles of the 1950's, with US strategic nuclear forces now supporting the use of TNW instead of vice versa. An example of a limited strategic option is presented in the report

on The Theater Nuclear Force Posture in Europe: "SLBM's provide highly-survivable means for striking WP air bases in response to WP nuclear attacks on NATO air bases."[10]

This example also illustrates the lack of a clear division between NATO's theater nuclear and US strategic nuclear forces. NATO's theater nuclear forces now include on-station US Poseidon and UK fleet ballistic missile submarines armed with US-supplied Polaris missiles as well as US F-111 and UK Vulcan medium bombers,[11] among others. If France should join in the military defense of Europe, NATO's theater nuclear forces would be reinforced with "several fleet ballistic missile submarines, a number of intermediate-range ballistic missiles, and bombers for strategic delivery of nuclear warheads."[12] In the example cited above, the SLBM's executing the strikes on Warsaw Pact air bases could just as well have been launched from a fleet ballistic submarine of NATO's theater nuclear forces as from a fleet ballistic submarine of US strategic nuclear forces.

An important point concerning the strategic capabilities of NATO's theater nuclear forces is that their role in the strategic balance must not be viewed as limited to offsetting the IR/MRBM launchers and medium bombers deployed near the western border of the Soviet Union. This perspective ignores the close deterrent interrelationships and potential defense interactions between the tactical and strategic capabilities of

NATO's theater nuclear forces. The highly-survivable strategic capabilities not only lend credibility to NATO's concepts for the use of TNW, but the in-theater ability to execute deep interdiction strikes is also useful in the event the use of TNW is not sufficient incentive for the Warsaw Pact to terminate the war on terms acceptable to NATO.[13] A similar point can be made also for US strategic nuclear capabilities, which could be used to reinforce NATO's theater nuclear forces with limited strategic options.

IMPLICATIONS

The deterrent interrelationships and potential defense interactions between NATO's theater nuclear and conventional forces and US strategic nuclear forces continue within the strategy of flexible response and under the conditions of strategic parity. NATO's theater nuclear and US strategic nuclear forces share the responsibility for deterrence of conflict escalation in Europe; these forces support each other in general nuclear war that might evolve from a war between NATO and the Warsaw Pact; and US strategic nuclear forces could be used to reinforce NATO's theater nuclear forces in situations short of general nuclear war, assisting in the defense against nuclear attacks by the Warsaw Pact. The growing offensive nuclear power of the Soviet Union has created doubts that US strategic nuclear forces remain coupled to the defense of Europe, but the doctrine as to the deterrence and defense roles for these forces, especially the provision for limited strategic options, should dispel such doubts.

NATO's in-theater strategic nuclear capabilities help to preserve coupling also because they can threaten or be used against other than battlefield targets and thereby serve to reassure US allies in NATO that

a nuclear conflict need not be confined to the territory of the Alliance. In addition, these strategic nuclear capabilities help alleviate the threat represented by the IR/MRBM and medium bomber forces of the Soviet Union, lending credibility to the doctrine that does not preclude first use of TNW by NATO forces. In-theater strategic nuclear systems provide a highly-survivable retaliatory capability which carries a perceptively lower risk of escalation than the use of US strategic nuclear forces if the Warsaw Pact should decide to respond to limited use of TNW by NATO. Operationally, NATO's strategic nuclear systems are interchangeable with and undistinguishable from like systems of US strategic nuclear forces.

Thus, an assessment of the strategic balance cannot be limited to a simple numerical comparison of nuclear assets, even if the total nuclear capabilities available to the United States and its NATO allies were contrasted with those of the Soviet Union and its Warsaw Pact allies. The inclusion of qualitative differences, such as delivery system accuracies and other technological factors, might improve the measure of the strategic balance, but the complexities probably would defy general understanding. For completeness, portrayal of the strategic balance must take into account the dissimilar nuclear doctrines of NATO and the Warsaw Pact and involve judgment as to the likelihood that doctrinal assertions will be carried out. In the final analysis, the reality of the strategic balance may be solely in the perceptions of national leaders on both sides.

US leaders may view the strategic balance as a desirable condition that helps to preserve international stability and serves to avoid the use of

nuclear weapons in war. Other NATO leaders may see the strategic balance as a condition that forces serious consideration of the need to improve their conventional force capabilities and raises doubts over the continuing utility of the nuclear deterrent. Warsaw Pact leaders might perceive the strategic balance as the realization of their aim of creating a correlation of forces which favors them because of their advantage in conventional forces over NATO. The leaders of the Soviet Union may view the strategic balance as eliminating the threat that NATO leaders might use nuclear weapons if they are losing a conventional war in Europe.

Whatever the perceptions of national leaders in peacetime, their outlook could change drastically in war. If NATO leaders could decide on the early use of TNW in response to an overwhelming conventional attack by the Warsaw Pact, the advantage would no longer lie on the side with big battalions. The first use of TNW by NATO forces, delivered with restraint yet with sufficient shock and decisiveness to change the perceptions of Warsaw Pact leaders, could tip the strategic balance in favor of the West. The choices for Warsaw Pact leaders would be to retaliate or to negotiate. Since NATO plans for first use of TNW would include an alert of US strategic nuclear forces as well as theater nuclear and conventional forces, the effectiveness of any form of retaliatory response, tactical or strategic, would be greatly diminished, and the readiness of the total nuclear power of the Alliance would constitute a threat that should discourage a nuclear response by the Warsaw Pact.

The impact of TNW on the strategic balance lies in US policy which does not preclude the first use of TNW by NATO forces. This aspect of NATO nuclear doctrine has not been changed by strategic parity, and for so long as it remains unchanged and NATO (including the United States) maintains highly-survivable second-strike capabilities and essential equivalence in strategic nuclear forces, NATO will have the advantage over the Warsaw Pact. An essential element of this advantage which must be retained is the uncertainty in the minds of Warsaw Pact leaders as to what circumstances must prevail before NATO initiates the use of TNW. This uncertainty is the key to the deterrence of large-scale conventional aggression just as NATO's second-strike capabilities deter nuclear aggression. TNW lend stability to the strategic balance in peacetime and have the potential to make the strategic balance work for NATO in war.

ENDNOTES

1. Harlan Cleveland, NATO: The Transatlantic Bargain, p. 81.

2. Richard Nixon, U.S. Foreign Policy for the 1970's: A New Strategy for Peace, p. 122.

3. Ibid., p. 33.

4. James R. Schlesinger, The Theater Nuclear Force Posture in Europe: A Report to the United States Congress in Compliance with Public Law 93-365, p. 2.

5. James R. Schlesinger, Annual Defense Department Report, FY 1975, p. 38.

6. The Theater Nuclear Force Posture in Europe, op. cit., p. 8.

7. Ibid., p. 15.

8. Ibid., p. 14.

9. Ibid.

10. Ibid., p. 13.

11. Donald H. Rumsfeld, Annual Defense Department Report, FY 1977, p. 99.

12. Ibid.

13. The Theater Nuclear Force Posture in Europe, p. 15.

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MEASURES OF THE STRATEGIC BALANCE

A Proposal for the IISS Workshop

The problem of measuring the effectiveness of strategic nuclear forces is a matter of importance as interested observers attempt to assess the relative strengths of the rival nuclear powers. In the world balance of power, the nation that is perceived to have an edge in strategic nuclear systems will accrue military and political advantages likely to be denied its adversaries. The probability that nuclear weapons will not be used is very high, yet the political and psychological value of having them is also perceived to be very high. This anomaly, therefore, adds importance to the exercise of calculating nuclear force size and effectiveness.

The International Institute for Strategic Studies (IISS) provides a very valuable service by compiling unclassified data on the relative size of nuclear forces worldwide. While IISS provides excellent data on quantities of missiles, it would be very helpful if some indicator of force effectiveness could be added to the factors shown in the Military Balance "Tables of Comparative Strengths." As the IISS Conference Agenda suggests, the data they now present do not give the reader much help in analyzing the military utility of the weapons described.

The question of "measures of effectiveness" is an extraordinarily complex subject if one is trying to build a gaming methodology that will determine which side will win a war in a given scenario. There are a number of critical variables that must be taken into account. The following factors all interact in the calculations of the strategic planner:

Number of launchers

Number of warheads

Warhead yield

Warhead accuracy

System reliability

Penetration Capability

Type of Target (Targeting Doctrine)

Desired damage level

Strategic planning assumptions

Tactical planning assumptions

The field of strategic planning in this operational mode is highly technical and is largely limited to operations analysts who have access to large computers and extensive intelligence data. The computer programs that can handle all these variables and still allow for changes in strategy and tactics are highly complex and very expensive.

However, such detailed and massive calculations are not necessarily required in order to increase one's appreciation of the strategic balance. Likewise, they are not required in order for IISS to present a very useful set of data on the comparative strengths of nuclear weapons systems.

One simple index of gross effectiveness for a given system is megatons, i.e., yield of the warhead. A slightly more sophisticated version of yield is equivalent megatons (EMT). EMT discounts the effectiveness of large yield weapons against point targets by applying a simple formula: $EMT = Y^{2/3}$. The radius of lethal blast area is proportional to the 1/3 power of weapon yield while the area is proportional to the square of the radius. This in effect establishes a diminishing return on increases in weapon size and notes that increases in destruction are not in direct proportion to increases in yield.*

EMT levels off the apparent differences in the effectiveness between the smaller, more accurate warheads of the United States and the larger ones of the Soviet Union. The $Y^{2/3}$ formula in effect says, all other things being equal, that doubling the yield of a single warhead does not double the effectiveness of the weapon except in the narrow case where the increase was needed to optimize weapon size against a specific target.

*Quanbeck, Alton H. and Barry M. Blechman, Strategic Forces, Issues for the Mid-Seventies, Washington D.C.: The Brookings Institution, 1973.

Accuracy of the delivery system is one of the most important factors in calculating effectiveness against point targets. While increases in yield must be discounted because capability does not increase in direct proportion to yield, accuracy must be given added weight because weapon capability increases with the square of accuracy. This means that doubling accuracy increases effectiveness fourfold while an eightfold increase in yield would be needed to achieve the same end.

In calculating a "lethality index" for a weapon system, a formula is required that takes both yield and accuracy into account. Kosa Tsopis, writing in Scientific American in July 1975 discussed a formula where $K = Y^{2/3}/C^2$ in which

K = Lethality

Y = Yield

C = Circular Error Probable

In this relationship EMT ($Y^{2/3}$) is divided by the CEP squared (C^2). This takes into account the important fact that improvements in accuracy are far more important than increases in yield. This relationship holds true until the limits of the problem are approached, that is, when the CEP is less than the size of the crater at which point further improvements in CEP are irrelevant.

A further variation of the formula, for weapons with multiple independently targeted reentry vehicles (MIRV), adds W for number of MIRVed warheads and the formula then becomes

$$K = Y^{2/3}/C^2 \cdot W$$

For the Minuteman III:

$$K = \frac{.170^{2/3}}{.25^2} \cdot 3$$

$$K = 14.72$$

For the Soviet SS-18:

$$K = \frac{1^{2/3}}{0.5^2} \cdot 5$$

$$K = 20$$

These figures give the reader a useful index upon which to make comparisons between these two weapons systems. If the IISS wished to make an estimate on overall systems reliability, this number could also be applied to the index to further refine the calculations. If a reliability of 0.8 were assigned to MMIII and 0.6 to the SS-18 then:

$$K = 14.72 \cdot 0.8 = 11.77 \text{ for MMIII}$$

and

$$K = 20 \cdot 0.6 = 12.0 \text{ for SS-18}$$

Accuracy is very important if one is trying to calculate the capability of a weapon system against pinpoint hard targets such as ICBM sites. It is not nearly as critical in the calculus of effectiveness against soft area

targets like cities, industrial areas, or military bases. Geoffry Kemp, in his Adelphi Paper Number 106 "Nuclear Forces for Medium Powers," suggests that the area over which a specified overpressure occurs is a useful measure of the capability of reasonably accurate warheads against urban/industrial soft targets. He shows the following data in a table on page 18 of his study:

YIELD	5 PSI	10 PSI
20 KT	4.3 sq. miles	1.8 sq. miles
100 KT	13.6 sq. miles	5.4 sq. miles
500 KT	36.4 sq. miles	16.2 sq. miles
1,000 KT	60.0 sq. miles	23.7 sq. miles
20,000 KT	447.0 sq. miles	180.0 sq. miles

Five PSI overpressure will cause moderate to severe damage to most structures in the typical urban area and will cause extensive casualties to the population of the area affected.

The area covered by 5 PSI can readily be calculated given weapon yield and height of burst. If height of burst is optimized for weapon size, then a maximum area for each weapon system could be computed. This figure, expressed in square miles, could be used as an index of weapon effectiveness against large, soft targets.

Another parameter in the strategic balance is the amount of weight that the missile force can boost onto target. This "throwweight" should be included in the IISS assessment because it is important when considering the growth potential of the large volume missiles. While throwweight is not a direct factor in force capability equations, it is none-the-less very important. In the final analysis, it constrains weapons yield and it sets the outer limits on numbers of reentry vehicles. Prior to the SALT accords, when numbers of launchers were not constrained, throwweight was not nearly as important as it is now under the SALT constraints.

Based on the foregoing discussion of some of the various indices available, it is recommended that the IISS revise its "Tables of Comparative Strengths" to include estimates and calculations on accuracy, reliability, EMT, lethality against point targets ($K = Y^{2/3}/C^2 \cdot W$), lethality against area targets (square miles @ 5 PSI), and throwweight. A suggested format for the table is attached.

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1. Nuclear Delivery Vehicles: Comparative Strengths and Characteristics

A. United States

Category	Type	Maximum Range (NM)	Number of Warheads (W)	Yield of Warheads (Y)	Number Deployed	Throw Weight	CEP (NM) (C)	Systems Reliability (R)	EMT* $Y^{2/3}$	Point** Target Lethality (K)	Area*** Target Lethality (sq mi)
ICBM	LGM 80 G Minuteman III	8000	3	.170mt each	550	****	.25	0.8	.92mt each	11.77	18.4

Footnotes:
*EMT = $Y^{2/3}$
**K = $Y^{2/3}/C^2 \cdot W \cdot R$
***Square miles @.5 PSI Overpressure
****No unclassified estimate available at the Air War College

THE STRATEGIC NUCLEAR BALANCE
MEASURED IN TERMS OF RELATIVE POST-WAR STRENGTH

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Introduction

It is generally recognized that measures, whether they are measures of situations or measures of system value, must be tailored to fit the purposes and objectives of the interested parties and to fit also the prevailing or postulated circumstances within which a situation or system is to be assessed. It is also generally recognized that formulation of measures which cut to the essence of a problem and are at the same time amenable to adequate quantitative treatment is as much an art as a science.

It is relatively easy to find examples of measures which satisfy some but not all of the requirements just mentioned. For example, the subject of this workshop is the strategic nuclear balance. The preoccupation with the term "balance" in this workshop and the workshops to follow is itself a measure of the situation, i.e. a judgment on our military posture vis-a-vis our potential adversaries. If the situation were substantially more favorable, these workshops might be studying how to maintain superiority rather than how to measure the balance.

There are three distinctly different circumstances under which the strategic balance may be measured:

(1) Prior to hostilities, the balance being measured in terms of the forces each side has in inventory.

(2) At the end of a preemptive attack; the measure being the "sufficiency" of the defender's forces which would survive the attack.

(3) At the end of a two-sided exchange, the balance being measured in terms of the reserve forces remaining on each side.

It is the first of these circumstances which has in recent years tended to dominate our evaluations of the strategic nuclear balance as well as the negotiations for limitations on strategic forces. The terms used are of course the various static indices, i.e. the descriptors of the U.S. and Soviet strategic nuclear forces in the pre-employment period. Among these are the numbers of delivery vehicles, the throw-weight associated with these vehicles, and the numbers of warheads, equivalent megatonnage, hard target kill capability, etc. associated with this throw-weight. Static indices all too easily meet the criterion of being amenable to quantitative treatment. By being static or pre-employment quantities, however, they fail to address the heart of the problem. One of the principal characteristics of modern and projected nuclear weaponry is that the initial strike(s) can drastically alter the magnitudes of the opposing nuclear forces.

The second of these circumstances relates to the American concept of deterrence. The premise is that strategic nuclear superiority has no operational utility since the defender's surviving forces will be sufficient to inflict retaliatory damage unacceptable to any potential attacker. The measure, "sufficiency", is a measure of absolute strength rather than of the balance. It does not, however, address the question of what might actually occur should deterrence fail. A more serious shortcoming is that the evaluations of sufficiency have not taken into account Russia's extensive civil defense or "war survival" preparations.

Measuring the balance in terms of the reserve forces remaining at the end of a two-sided exchange addresses such questions as whether the Soviet strategic forces can defeat the U.S. strategic forces and whether the U.S.S.R. could emerge from a nuclear conflict with forces sufficient to control future actions of the United States and other nations. Such questions assume crucial importance if the Soviet civil defense protections have undermined or seriously weakened the U.S. present deterrence concept.

It is this latter measure of the balance, in terms of forces remaining at the end of a two-sided exchange, that is the focus of this paper. We recognize of course that such an intricate issue as the strategic nuclear balance cannot be confined to a single possible circumstance or be treated totally in terms of a single, easily understandable measure. On the other hand we recognize the necessity to provide top level decision makers with simple but fundamental concepts on which to base their decisions. This latter consideration has strongly influenced our approach to the analysis of the strategic nuclear balance.

A Recommended Approach to Measuring the Strategic Nuclear Balance

This approach assesses the strategic balance at the end of a two-sided exchange in which one side attacked the strategic forces of the other side and the defending side's surviving forces retaliated against the attacker's reserve strategic forces. For reasons outside the scope of this paper, attacks against urban centers were judged to be relatively unlikely and hence were not included in the assessment. Had such attacks been included it would have moved the balance further in favor of the Soviet Union because of the imbalance in civil defense capabilities.

In this methodology, the attacker is assumed to allocate his forces to achieve the parallel objectives to greatly diminish the defenders strategic nuclear forces and to gain the greatest net advantage at the end of the two-sided exchange, accounting for the defender's retaliation against the attacker's reserve force.[1] Hence (if throw-weight were used as the index of net advantage) the attacker's allocation does not consider merely whether a unit of his throw-weight expended would knock out a unit of the defender's throw weight; it considers in addition the potential of each unit of the defender's throw-weight, if left surviving, to knock out more

(1) It is possible to construct cases in which the dual objectives of greatly diminishing the defender's forces and of gaining maximum net advantage are not compatible. However, in all cases investigated to date involving present and projected forces, no serious incompatibility has been discovered.

than its own weight of the attacker's reserve force throw-weight. Consistent with this doctrine, the defender's retaliation is designed so that a unit of his throw-weight would knock out at least a unit of the attacker's reserve force throw-weight (or whatever index was being used).

The several segments of the interchange are illustrated in Figure 1. The five segments labeled A,B,C,D,E are not necessarily time sequential but represent a separation of different types of strikes. Segment A is a Soviet attack on U.S. bombers and SLBM bases; segment B is a Soviet ICBM attack on U.S. ICBM's. Segments C,D, and E are U.S. response strikes; C is an attack on Soviet bombers and SLBM bases, D is an attack on Soviet ICBM's, and E represents an expenditure of U.S. bomber capability.

The measurement of relative strength at the end of a two-sided exchange inherently accounts for all operationally important capabilities of the originally deployed forces. The assessment considers not only numbers of delivery vehicles and deliverable throw-weights but also accounts for delivery accuracies, MIRVing (numbers of warheads), and the survivability and operational limitations of both side's forces. Similarly, this approach to measurement eliminates some of the more troublesome analytical questions relating to the equivalence of bombers in the total bomber-missile force structure. The reason is that at the end of the exchange, the bomber forces are gone or are reduced to a relatively small portion of the total reserve force[2].

As will be illustrated in the following section, the choice of index to measure the post-interchange net advantage turns out to be a matter of relatively small importance. Parameters of great operational importance in deployed forces (e.g. accuracy) are either absent or of substantially reduced importance in the post-interchange reserve forces. Specifically, most of the very hard targets which could be attacked would have been attacked.

(2) To assume that bombers can be held as a significant part of a reserve force would (at least for bombers presently in existence or under development) require that a reasonable number of long runways survive. Either side could under most conditions deny to the other these runways at the cost of a relatively modest amount of their reserve force.

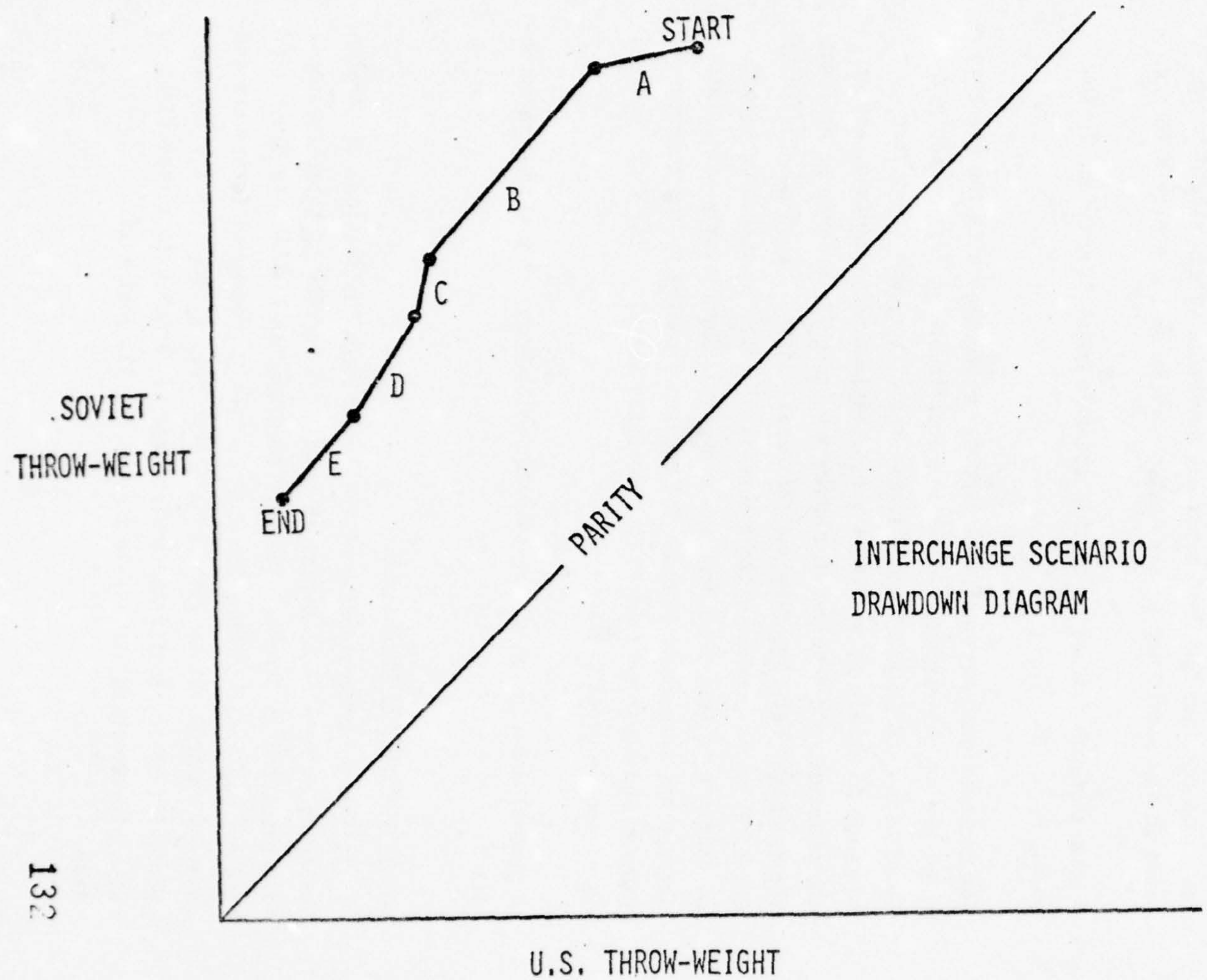
START
A
B
C
D
E
END
PARITY
INTERCHANGE SCENARIO
DRAWDOWN DIAGRAM
SOVIET
THROW-WEIGHT
U.S. THROW-WEIGHT

FIGURE 1

As indicated earlier each side designs its strikes to optimize the post interchange net advantage. Since operationally important capabilities such as accuracy and survivability are taken into account and both sides seek to optimize their relative advantage there is no reason to conclude that end point net advantage values should be related in any simple way to the static indices of the deployed forces.

A more thorough discussion of this scenario model is provided in Appendix A.

The computational methodologies used in conjunction with the scenario model are at one extreme very elementary, involving just an analyst armed with good judgment and a simple calculator, who seeks through a sequence of trials to arrive at a near optimum net advantage, and at the other extreme involve an elaborate computer program which finds the optimized net advantage and the corresponding strike compositions. Our early work was done without benefit of this computer program and we continue to work some problems manually. Surprisingly little difference has been found between the answers produced by the computer program and those arrived at by a seasoned analyst. The time required is of course greatly different.

A general description of the computer methodology is provided in Appendix B.

An Assessment of the Balance

To facilitate understanding of the longer term implications of strategic programs as well as of forces in being, the results of this assessment are presented as trends. The data displayed in Figure 2 is typical of the results obtained when the U.S. currently programmed forces are considered in conjunction with Soviet force projections. In the exchange producing these results the Soviet side was assumed to attack first and each side designed its strike to optimize its post interchange net advantage.

Comparison of Throw-Weight and Equivalent Warheads Differentials

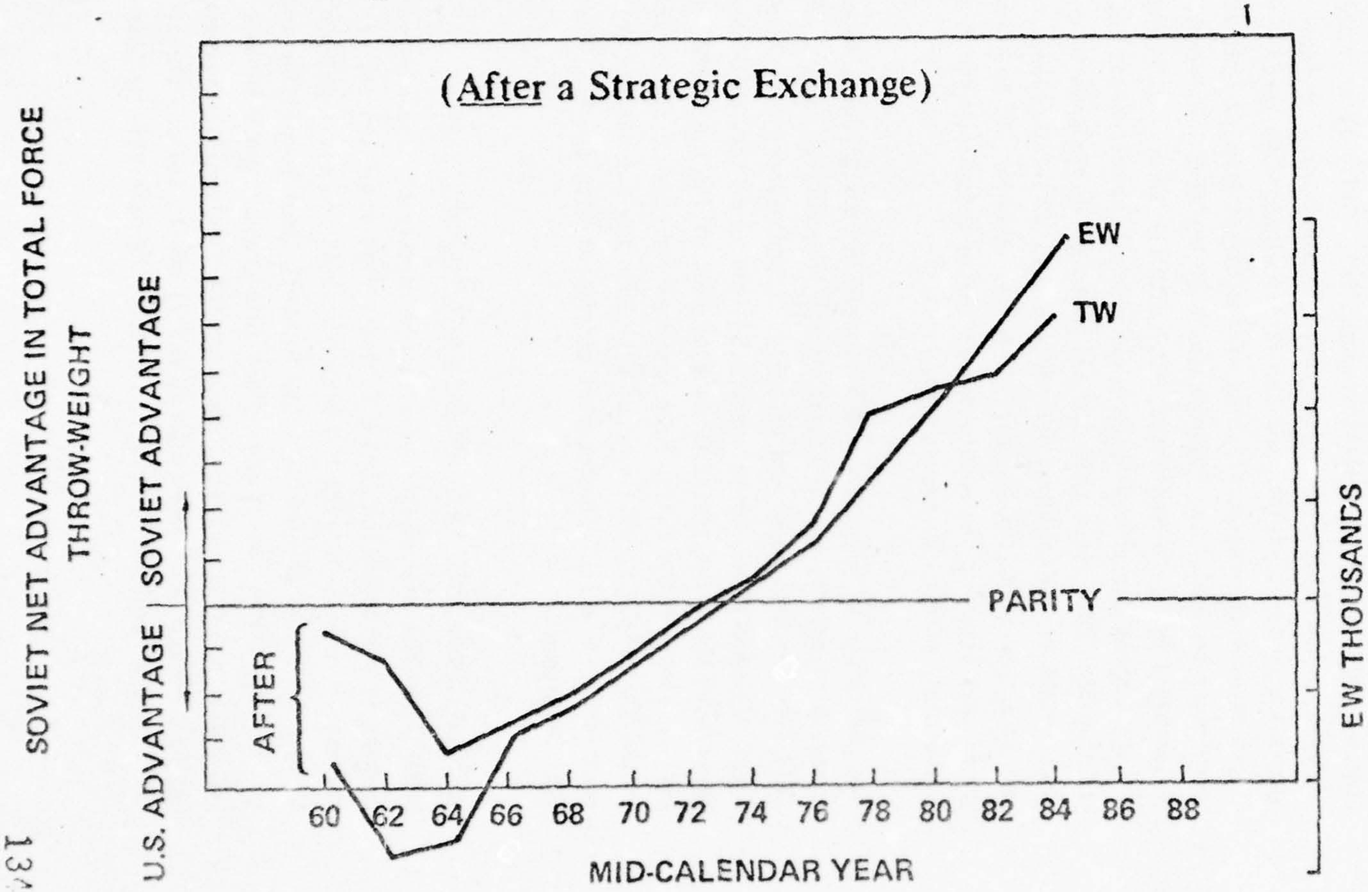

FIGURE 2

The figure shows the relative balance both in terms of total force throw-weight and of equivalent weapons (EW). This latter index, developed by R&D Associates, is of considerable interest because it engages the numbers, yields, and accuracies of residual force weaponry together with the characteristics of the target complex against which they might be used. The figure shows that the trend in terms of post-interchange EW is virtually identical with the trend in throw-weight. Figure 3 shows corresponding data for commonly used indices less encompassing than EW. These data are all based on an exchange in which each side sought to gain maximum net advantage in post-interchange throw-weight rather than, for example, warheads. However, it has been determined that altering the exchange doctrine to optimize warheads does not discernibly affect the trends shown.

The indication of Figures 2 and 3 is that the Soviet Union is moving steadily toward the capability to emerge from nuclear combat with the United States with major and possibly dominant superiority in all indices of capability. The present U.S. lead in numbers of warheads disappears in about two years, marking the end of the U.S. MIRV programs and the start of the Soviet MIRV programs. Moreover, the trends shown assume that the U.S. will proceed with both the B-1 and the Trident programs and that a SALT II agreement consistent with the Vladivostok accord will be signed.

Impact of Civil Defense on the Strategic Nuclear Balance

Underlying most discussions of strategic deterrence and strategic nuclear balance is a presumption that U.S. and Soviet value systems are comparably vulnerable to nuclear attack. Soviet emphasis on civil defense, leading to greatly increased survivability for both their population and their industrial/economic base, undermines this presumption. In this connection two questions arise: 1) how to measure the survivability/vulnerability of a nation's industrial/economic base, and 2) how to include the effect of such civil defense protection into measures of the strategic nuclear balance.

Alternative Indices of Strategic Capability
(After a Strategic Exchange)

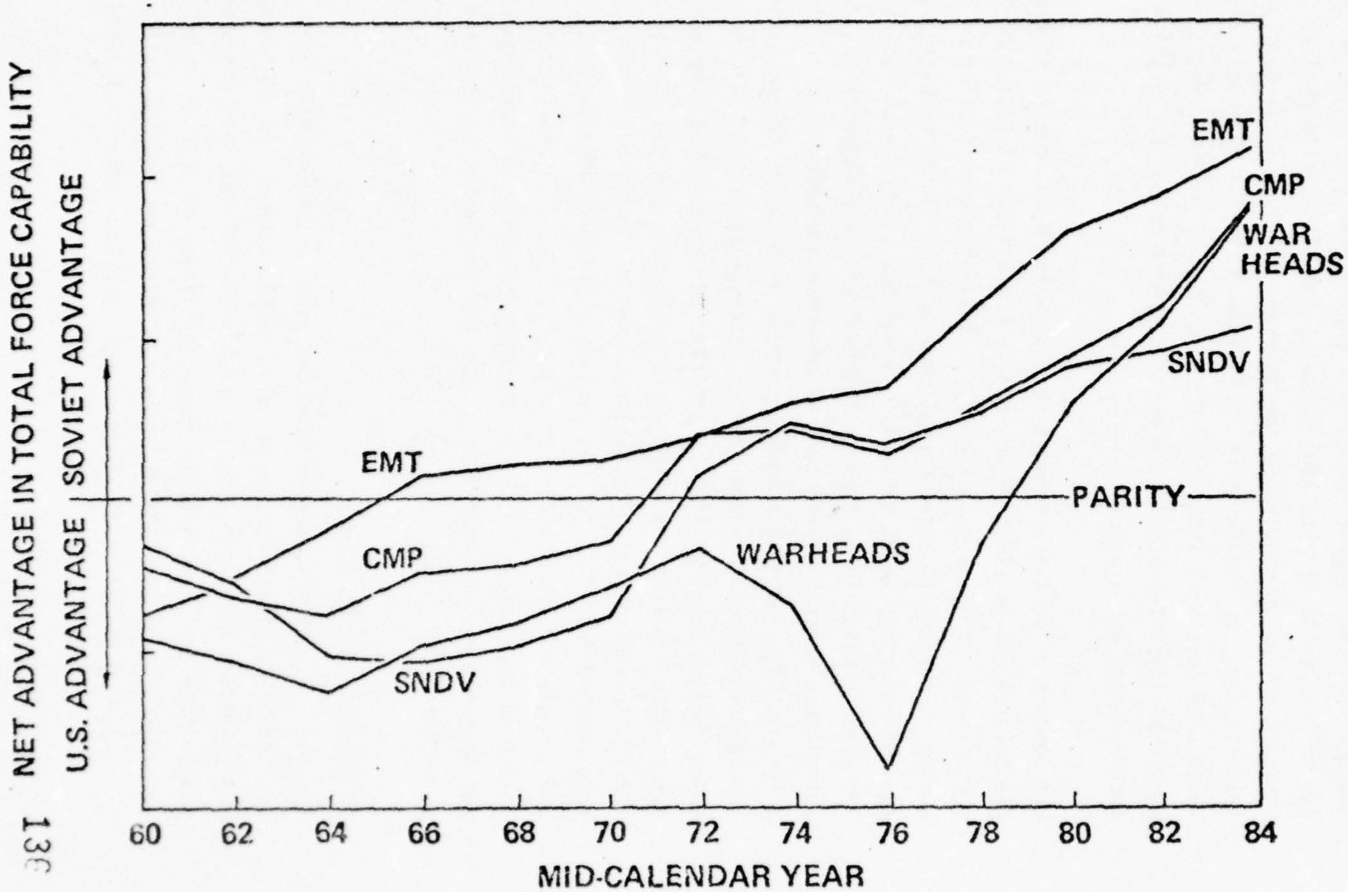

FIGURE 3

The approach usually taken in studies of retaliatory effectiveness is to measure the fractions of industrial/economic capacity which can be destroyed by various levels of attacking forces. (We find, incidentally, that the Soviet combination of planned and inherent survivability, multiple dispersed installations and hardening of facilities, makes it extremely difficult to reach high levels of industrial distruction). The more cogent measure of survivability/vulnerability, however, appears to be the length of time to recover after an attack.

The concept of post-interchange net advantage as a measure of the strategic balance can be extended to include the effects of Soviet civil defense protections. Referring to Figure 4, consider a continuation of the interchange in which both sides expend some portion of their reserve forces against adversary value systems. If neither value system has substantially improved survivability, then achievement of equal damage would require approximately equal expenditure of reserves, corresponding to a move from Y to point Z_1. Note this movement would be parallel to the parity line and would produce no change in the net advantage value. If, however, Soviet value systems survivability is greatly increased then a greater US reserve force expenditure is required to reach the same damage, corresponding to the Z_2 terminal point. The desired level of damage may indeed require more reserve force assets than remain available, as illustrated by Z_3. The translation from point Y to point Z_1, Z_2, or Z_3 represents the modification in approach to measuring strategic nuclear balance required to account for Soviet civil defense impact. Our studies of the balance are currently focused on this issue.

Assessment of Stability

The basic method illustrated here can also be used to gain some insight into the stability of the strategic relationship between the two powers. As in the preceding discussion, it is noted that the stability assessments portrayed here become critically important if one or both sides have implemented civil, air, or ABM defenses sufficient to limit to an acceptable level the potential retaliatory damage to urban-industrial areas.

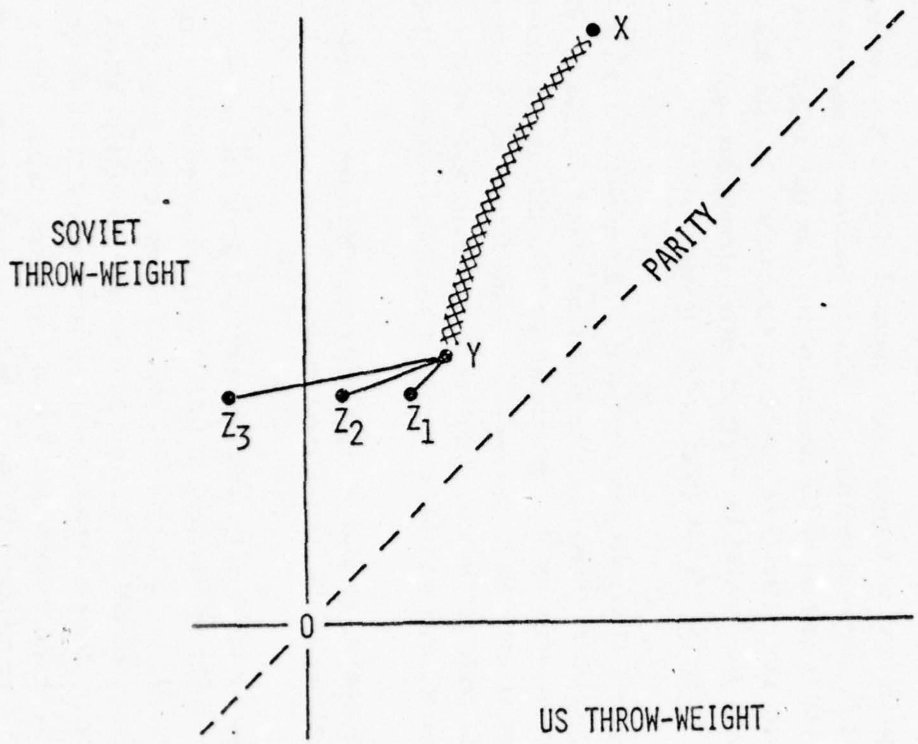

FIGURE 4

Figure 5 shows what is happening to the stability of the strategic relationship. It compares the post-interchange relationship with the relative balance that would exist before a Soviet attack. The data shows that in 1964 (for example) had the Soviets attacked U.S. forces, the result would have been to increase the U.S. advantage over what it was before the exchange. The strategic relationship at this point was stable. This year 1976, the "before" and "after" curves cross over, indicating that by attacking the U.S. strategic forces, the Soviets could increase their ratio of advantage over the United States. This condition is unstable.

The "before" or pre-employment curve of Figure 5 does not include bombers not on alert and reflects the missile throw-weight equivalent of warheads actually carried by the bombers rather than the maximum "payload" which could theoretically be carried by the bomber. To have done otherwise would have lowered the "before" curve, thereby making stability appear to be worse than is now shown by the figure.

Figure 6 illustrates an additional factor affecting the stability of the strategic relationship. The data shows that from 1966 to 1978 the Soviet net advantage would be greater if the U.S. initiated a nuclear exchange than it would be if the Soviets were the initiator. During this period the U.S. could retain some stability by exercising self restraint in a crisis. However, this possible condition of stability reverses in 1978.

The absolute margins of superiority may also have some influence on the stability of the strategic relationship.

Figure 7 compares the absolute margin of Soviet superiority with the levels that might be necessary to fulfill Soviet post-exchange requirements. By 1977, the Soviet margin will have increased to the point that they could destroy Chinese and European NATO nuclear capability, attack U.S. population, industry and conventional military targets, and still have a remaining force throw weight greater than that of the United States. This margin is in addition to the capabilities of the Soviet medium bomber and MR/IRBM forces which could replace strategic assets in accomplishing some of these functions.

Soviet – U.S. Throw-Weight Ratios

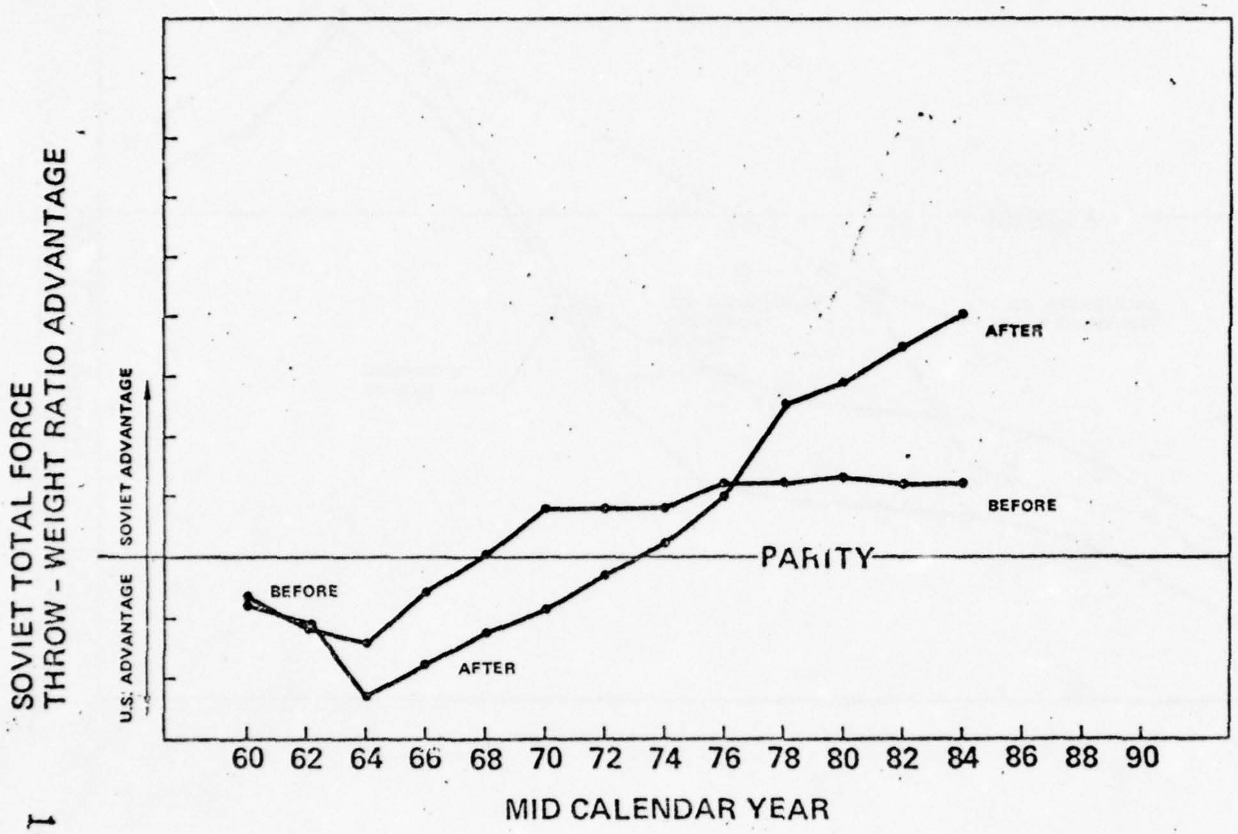

FIGURE 5

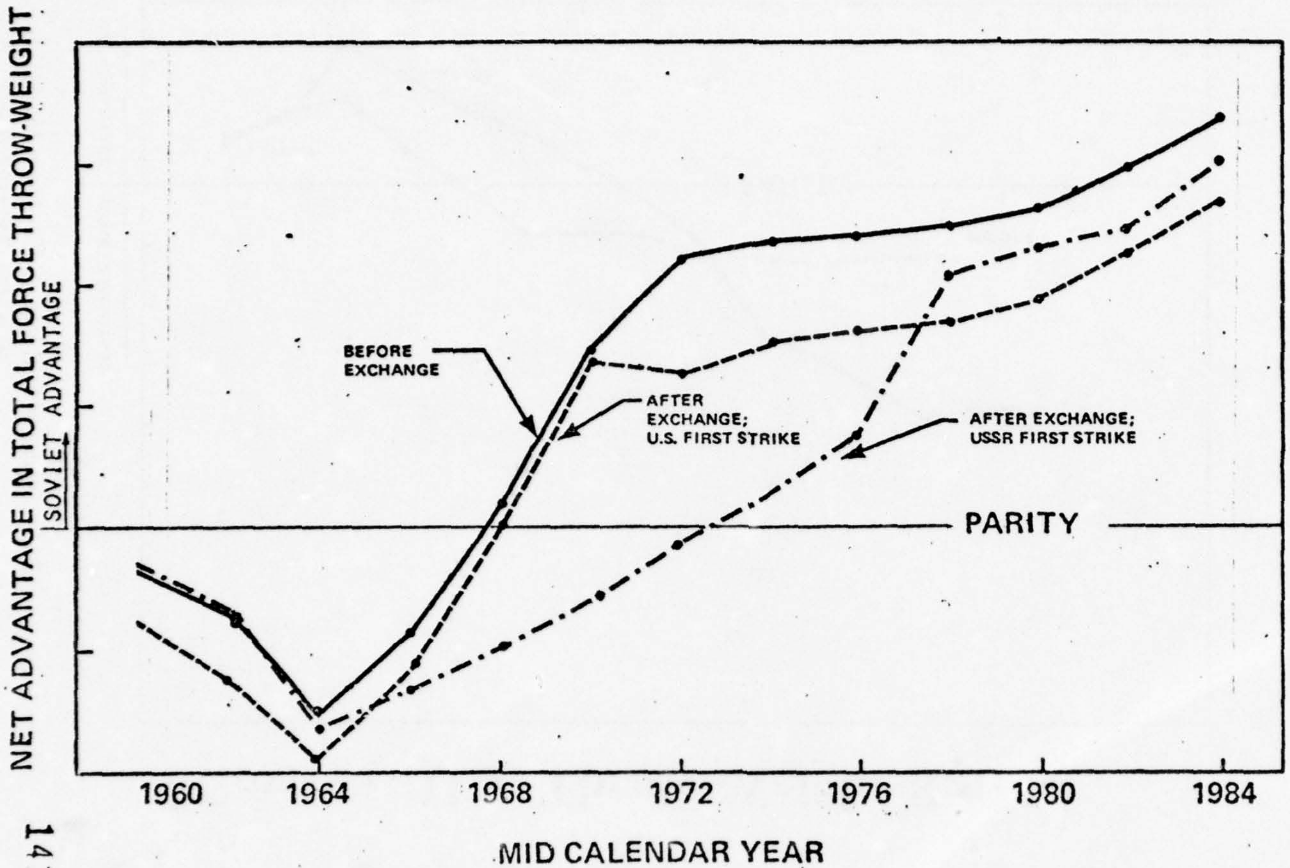
NET ADVANTAGE IN TOTAL FORCE THROW-WEIGHT
SOVIET ADVANTAGE
BEFORE EXCHANGE
AFTER EXCHANGE; U.S. FIRST STRIKE
AFTER EXCHANGE; USSR FIRST STRIKE
PARITY
1960
1964
1968
1972
1976
1980
1984
MID CALENDAR YEAR

FIGURE 6

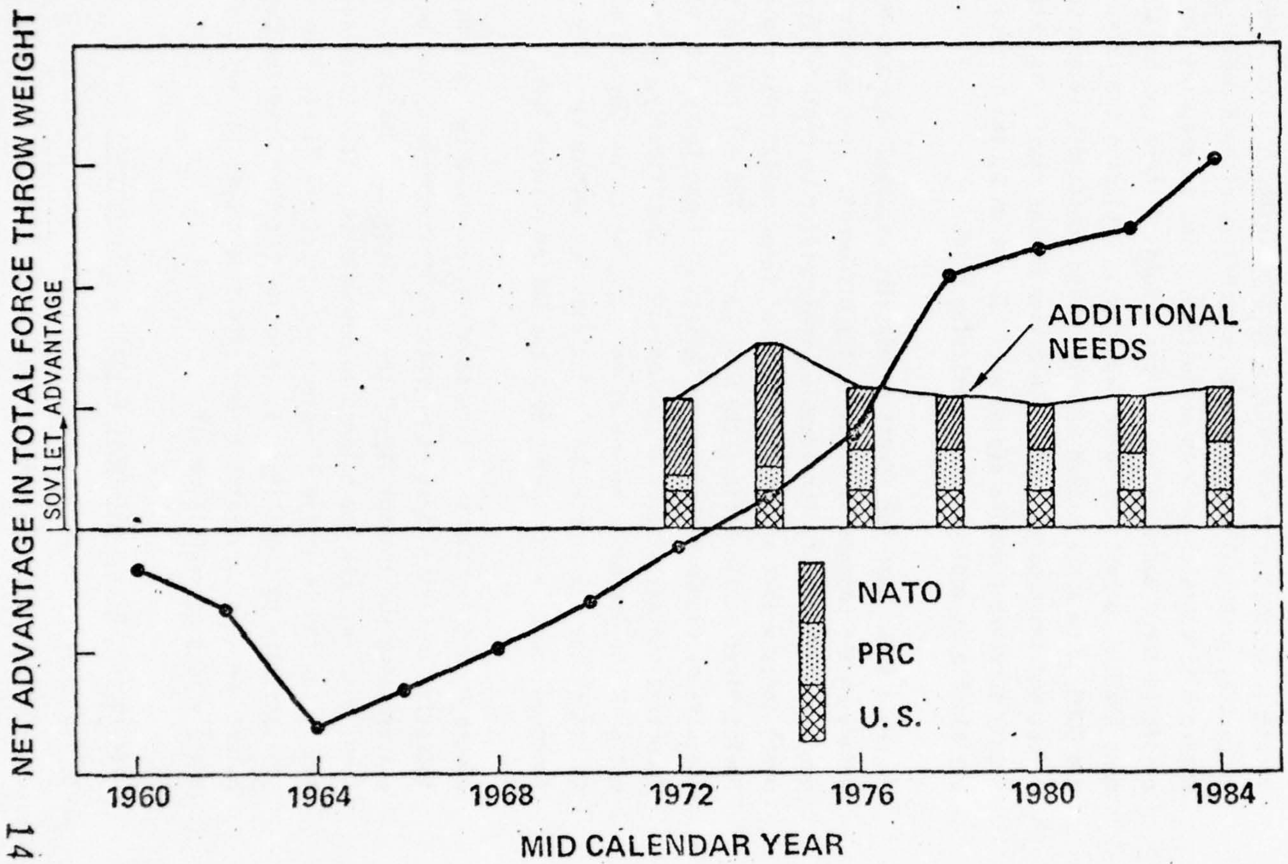
NET ADVANTAGE IN TOTAL FORCE THROW WEIGHT
SOVIET ADVANTAGE
ADDITIONAL NEEDS
NATO
PRC
U.S.
1960
1964
1968
1972
1976
1980
1984
MID CALENDAR YEAR

FIGURE 7

Evaluation of Strategic Force Structure Modifications

The method we are discussing can be used to evaluate the effect on the strategic balance of modifications to the strategic force structure and to portray graphically the effect on stability of such modifications. Figure 8 illustrates such an evaluation, using as examples two different candidate force modification options. Both of these options would augment the U.S. programmed force deployment, replacing the existing Minuteman ICBM, with a new MIRVed missile having substantially greater throw-weight and improved accuracy. In option M, the missile is based in a highly survivable mobile deployment. In option S, the increased capability missile is deployed in the existing silos.

Figure 8 shows that for identical missiles deployed in equal numbers the effect on the balance is dramatically different. Such options are usually compared in terms of, for example, their effect on deployed (pre-employment) throw-weight and on the amount of throw-weight that would survive a Soviet first strike against the U.S. forces. The method used to obtain the data of Figure 8 includes the effect of these factors as well as other important characteristics of the options. Specifically, it includes for option M the increased amount of inventory which the Soviets must expend to attack the U.S. force and it includes for both options the effect of improved accuracy in drawing down the Soviet reserve force.

Figure 9 compares the impact on stability of these two options. The Soviet incentive to strike first is increased significantly by option S, thereby exacerbating the instability of the relationship. Option M, on the other hand, both restores the balance to approximate post-interchange parity and eliminates the incentive of either side to strike first, thus contributing substantially to stability. It is worth remarking that for option M the balance between survivability and offensive capability was designed deliberately to produce this result.

Relationship of the Strategic Balance and Deterrence

It is important to again emphasize the fact that the strategic balance may or may not be related to the capability to deter nuclear war. The theories

COUNTERFORCE INTERCHANGE
SOVIETS STRIKE FIRST - BASELINE SCENARIO

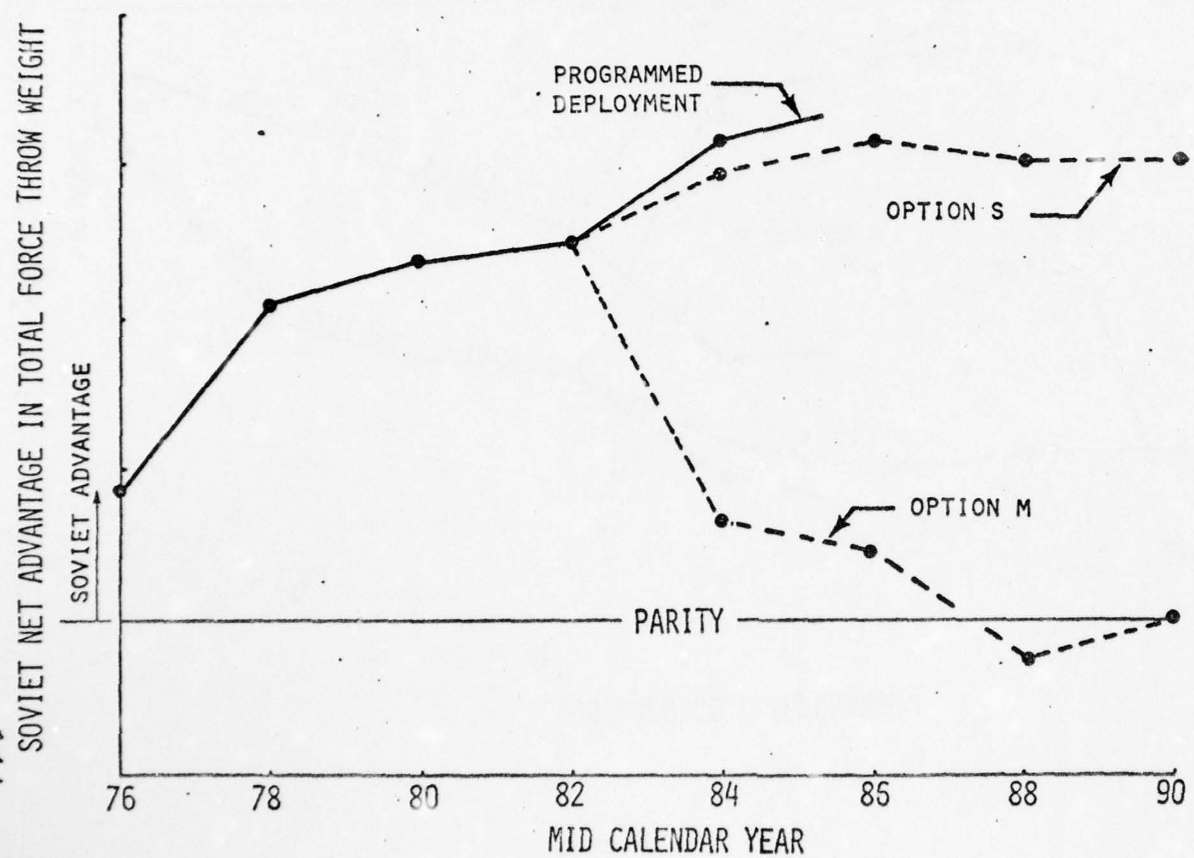

FIGURE 8

COUNTERFORCE INTERCHANGE

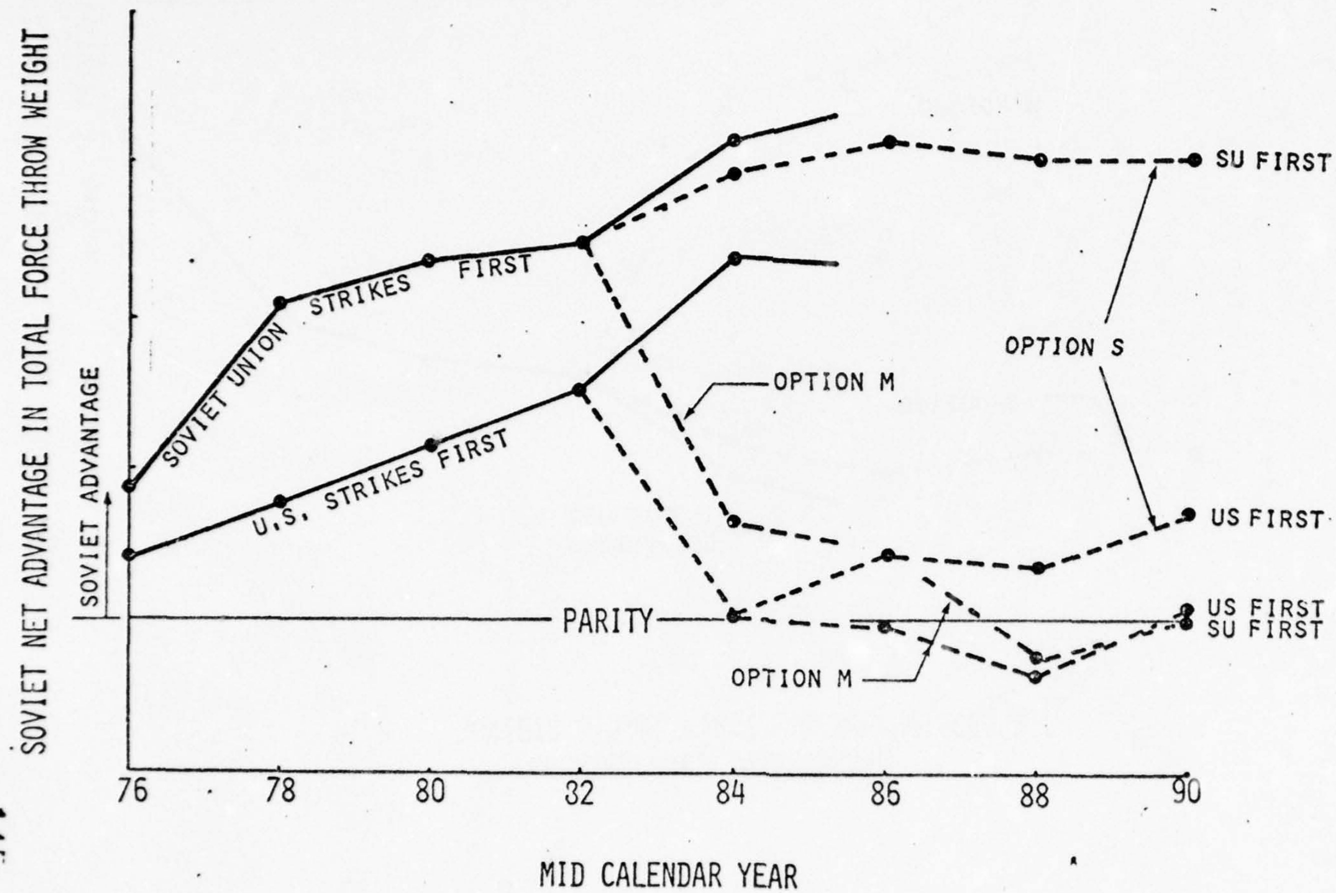

FIGURE 9

of the "Mutual Assured Destruction" concept of deterrence are such that the strategic balance is a moot question; deterrence would prevent operational employment by either side of even a vast superiority.

If, however, either side has civil, air, and/or ABM defenses capable of limiting to an acceptable level the retaliatory damage which could be inflicted by the other side, the condition and stability of the strategic balance may become a deciding factor in the capability to deter nuclear war. In this circumstance, a strong deterrent would exist if the balance at the end of the exchange would be significantly in favor of the defending side, no matter which side attacked first.

A further consideration is that continuation of the decline in Northern Hemisphere mean temperature could lead to serious starvation in the Soviet Union. Never in history has a militarily strong nation permitted itself to starve. To a strong nation facing starvation, a threat of population fatalities from nuclear war could be an incentive rather than a deterrent. More importantly, the most probable scenario would be one of nuclear blackmail to coerce shipment of food, rather than to attack the other side's forces. In such a condition, the relationship between the strategic balance and deterrence would be difficult if not impossible to assess.

Summary

The relative strength of Soviet and U.S. reserve forces subsequent to a two-sided counterforce interchange is recommended as a measure of the strategic nuclear balance. This measure takes into account all operational characteristics of the forces and exercises employment options available to both sides.

This measure readily lends itself to evaluation of force modification options and of currently programmed forces as well. Trends in the balance are also readily portrayed.

Soviet civil defense measures impact the strategic nuclear balance; one approach for including this effect into the recommended measure of the balance has been suggested.

APPENDIX A: BASELINE INTERCHANGE SCENARIO

As previously noted, the baseline interchange scenario consists of a two-sided strategic nuclear exchange initiated by the Soviets with the objective to greatly reduce U.S. throw-weight while retaining or gaining Soviet throw-weight superiority. The five steps illustrated in Figure 1 are not necessarily time sequential but represent a separation of different types of strikes.

The five exchange steps are labeled A through E. Step A is the Soviet attack on U.S. bomber bases and SLBM bases; step B is the Soviet ICBM attack on U.S. ICBM's. Steps C, D, and E are retaliatory U.S. strikes; C is the attack on Soviet SLBM's and bomber bases, D is the attack on Soviet ICBM's, and E represents the expenditure of U.S. bomber capability. Each step will be described separately.

STEP A: SOVIET ATTACK ON U.S. SLBM AND BOMBER BASES

In this step the Soviets attack U.S. submarine and bomber bases using SLBM's, SSN-8 missiles or "new" SLBM's, and destroy U.S. SLBM's in port plus 12% of the alert bomber throw-weight.

It is assumed that 37% of U.S. SLBM's are in port and hence destroyed by the initial Soviet attack. This figure is derived from an at-sea rate of 67% for Trident an at-sea rate of 55% for Poseidon and an additional assumption that 10% of the U.S. SSBN's normally in port are gotten out of port in the brief period of warning preceding the Soviet attack. All of the U.S. at-sea submarines, including those in transit, are assumed to survive.

The 12% figure for the bombers assumes that all alert B-1 aircraft escape and all but about 30% of the alert B-52's escape. This corresponds to no Soviet submarines closer to U.S. coasts than 200 n. mi., none in Hudson Bay, and presumes that all U.S. warning systems are intact and that sufficient tankers survive to satisfy refueling needs. Alert rates of 60% and 40% are assigned to the B-1 and B-52 respectively.

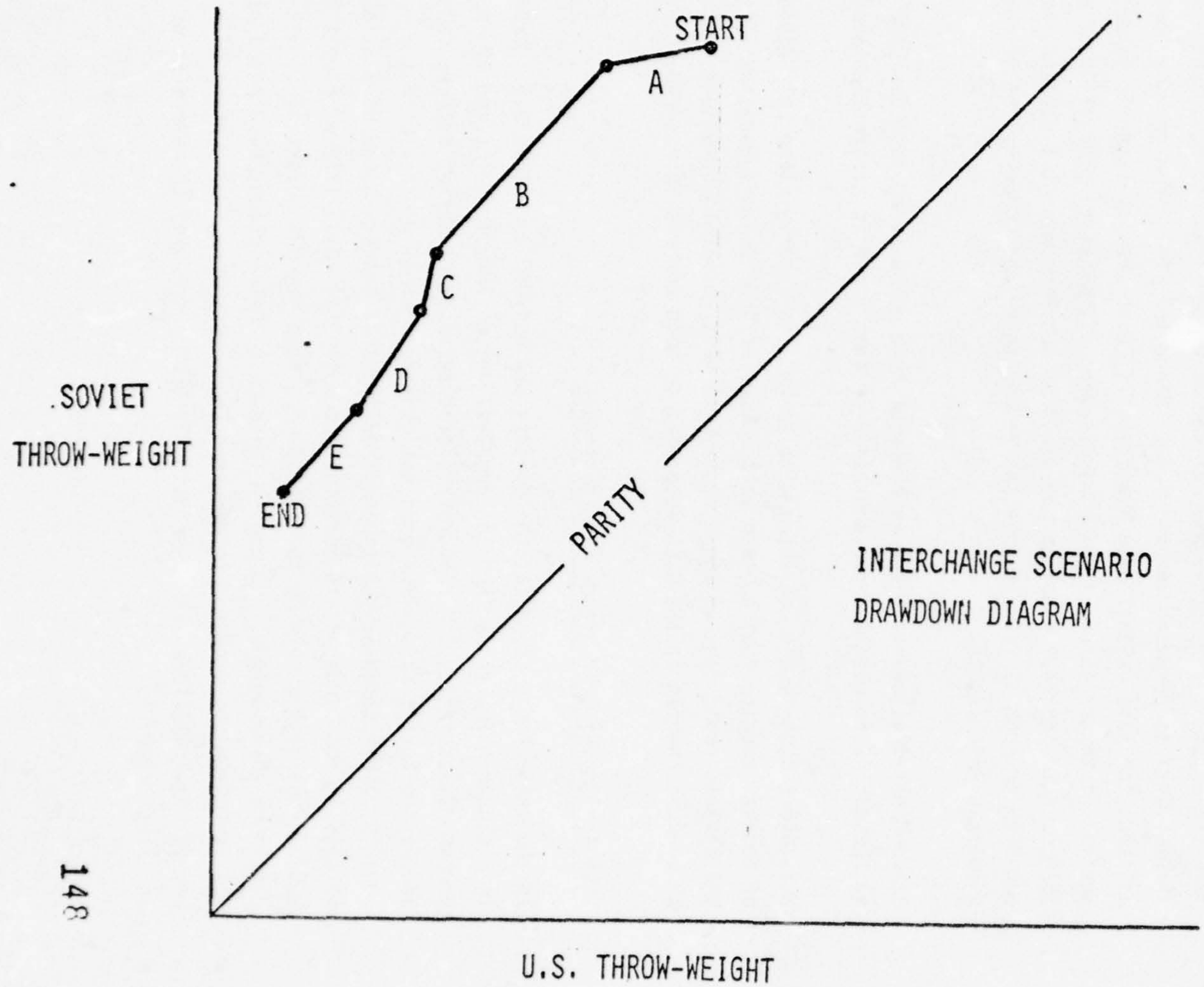
START
A
B
C
D
E
END
PARITY
SOVIET THROW-WEIGHT
U.S. THROW-WEIGHT
INTERCHANGE SCENARIO
DRAWDOWN DIAGRAM

FIGURE 1

The before-strike bomber throw-weight is the product of the number of alert aircraft, the probability of penetration, and the equivalent throw-weight per bomber. Bomber equivalent throw-weight is based on the weapons which the bombers could deliver to targets. The B-1 payload is nominally 8 gravity stores and 12 SRAM or ALCM. The B-52 G/H nominally carries 6 SRAM and 4 bombs. The conversion of bomber weapon loads to equivalent throw-weight is based on weapon yield. Since the yield of a gravity bomb is about the same as that of a Minuteman II, each gravity store is taken equivalent to the throw-weight of a Minuteman II missile. The yield of one SRAM or ALCM is about equal to the yield of one Minuteman III warhead, hence one SRAM or ALCM is taken equivalent to one third the throw-weight of one Minuteman III missile.

Assumed penetration rates for each bomber type decrease as calendar year increases. Data used is representative of that found in penetration studies.

U.S. alert bombers are not assumed to be held in reserve since this would, of course, require that a reasonable number of long runways survive. Since the Soviets could deny us these runways at very modest throw-weight cost, they would benefit if the U.S. attempted to hold bombers in reserve.

STEP B: SOVIET ICBM ATTACK ON U.S. ICBM's

In the interchange scenario, the Soviets are assumed to attack U.S. forces in a manner which gives them the greatest net advantage at the end of an exchange, accounting for U.S. retaliation against the Soviet reserve forces. Hence, the Soviet allocation does not consider merely whether or not a pound of their throw-weight expended destroys at least a pound of U.S. throw-weight; it must consider in addition the potential capability of a unit of U.S. forces left surviving to destroy more than its own weight of Soviet remaining throw-weight. Naturally in the U.S. retaliation, each pound of U.S. throw-weight expended is required to destroy more than a pound of Soviet remaining force throw-weight. No SLBM's are used to attack silos on either side.

STEP C: U.S. RETALIATION AGAINST SOVIET SLBM AND HEAVY BOMBER BASES

Since the overall exchange is initiated by the Soviet, a high alert rate is postulated and all Soviet SLBM's not normally in repair or overhaul, 80%, are assumed to be at sea. The remaining 20% are killed by the U.S. strike against the bases. Soviet heavy bombers, including Backfire, are assumed to be sustainable on 60% airborne alert; the remaining 40% are destroyed.

This retaliation action is accomplished by surviving U.S. ICBM and/or SLBM weapons.

STEP D: U.S. ATTACK ON SOVIET ICBM'S

This attack is carried out by U.S. ICBM's or, when ALCM is available, by a combination of ICBM's and bomber-launched ALCM's. In this baseline interchange scenario ICBM's are not attacked by bomber gravity weapons, bomber SRAM weapons, or SLBM's. ICBM silo regions are presumed to be too heavily defended to permit bomber attack except with the long range stand-off ALCM weapon.

The baseline scenario allows the designer of this response strike against Soviet ICBM's to know how many of each Soviet ICBM type have been expended in the Soviet strike-first action, but no further information about the locations of unused ICBM's. (The FOREM computer model permits also the alternative assumption that locations of unused ICBM's are completely known)

STEP E: U.S. BOMBERS vs SOVIET BOMBER RUNWAYS

The final step in the drawdown accounts for use of the U.S. bomber forces throw-weight surviving step A. All U.S. bomber throw-weight is assumed to be used, since as previously noted, we cannot hold it in reserve. Soviet bomber throw-weight on the other hand can be retained as a reserve under circumstances where the U.S. lacks the weapons to destroy most of the runways within bomber range of U.S. targets and non-belligerent recovery bases.

The airborne alert aircraft cannot be destroyed unless almost all of their operating runways are destroyed. To destroy a runway so that it could not be quickly returned to operation requires a relatively large, accurately placed weapon such as the B-1 gravity store.

There are a large number of runways from which a Backfire can reach U.S. targets (recovering in Cuba). Some of these runways have sufficient length that even when divided would have segments sufficient for takeoff and landings. When these additional aimpoints are included, a total set of aimpoints can be designated. It is assumed that until the majority of these aimpoints are attacked, the entire Backfire force remains usable. Further, it is assumed that when two weapons have been delivered against each of these aimpoints most of the Backfire force is negated.

APPENDIX B: FOREM METHODOLOGY

Red and Blue are two adversaries each with an array of nuclear strike weapons of different types which can be used against the other's nuclear strike weapons. Red strikes first and Blue responds. The problem of interest is to determine the compositions of the Red and Blue strikes which produce a result optimized for both Red and Blue. The quantity optimized is Red's residual throw-weight minus Blue's, or the difference between any two functions which are respectively linear in the residual numbers of Red and Blue nuclear strike weapons. The problem then is to find

$$\text{maximum}\left\{\text{minimum}\left[\text{Red residual value - Blue residual value}\right]\right\}$$

wherein for every specified Red strike the minimum is sought over all possible Blue response strikes and the maximum minimum is sought over all possible Red strikes.

A computer program, FOREM, has been built to work this maximum minimum problem. In the following material the process of finding the minimum is referred to as the "inner optimization"; the process of finding the maximum minimum is called the "outer optimization".

The inner optimization is accomplished using a linear programming approach. In Blue's response strike the n-tuple $(x_1,x_2,---,x_n)$ describes an allocation of weapons against a given target, i.e., x_1 of weapon type 1,x_2 of weapon type 2, etc. Such an n-tuple is called a strike element and Blue's response strike consists of <u>exactly one</u> strike element assigned to each target in the target complex. The values x_i determine the <u>type</u> of the strike element. Elements $(a_1, a_2, ---, a_n)$ and $(b_1, b_2, ---, b_n)$ are of the same type if $a_i=b_i$ for all i, otherwise they are of different types. If $s_{\alpha\beta}$ is the number of strike elements of type α allocated against the Red type β target set, then the total Blue value used in the response strike and the total Red value destroyed by that strike are both linear in the $s_{\alpha\beta}$ and of course the difference between the two is also linear in the $s_{\alpha\beta}$. The constraints are also linear. For example, if type α strike element includes $x_{\alpha j}$ of the type j weapons then $\sum_{\alpha\beta} s_{\alpha\beta}x_{\alpha j}$ = the number of type j weapons remaining in Blue's force after the Red strike.

The problem is thus formulated as a linear programming problem and is handled by standard techniques.

The basic variables of the outer optimization are Z_{ij}, i.e., the numbers of Red type i weapons allocated against the set of type j Blue targets. For any selected set of Z_{ij} there is, then, for any given j a set of weapons of different types allocated against this target type. The optimum allocation of this set of weapons over the type j targets is formulated and solved as a linear programming problem (maximizing the type j value destroyed) using the same approach as for the inner optimization. Doing this for all j produces a complete description of the Red strike, i.e., the specific allocation of weapons against each target is determined. This in turn provides the input data for the inner optimization which then follows.

The strike interchange is thus determined for any specified Z_{ij}. It remains to search the Z_{ij} space for the variables producing the maximum minimum. This search is conducted using a general purpose software package called AESOP which incorporates and exercises in specified sequence a multiplicity of search techniques. The specification of the techniques, their sequence of utilization, and the criteria for shifting from one technique to another are all determined by the analyst. This determination depends on the nature of the particular problem at hand and is done on the basis of accumulated experience.

In its present state of development FOREM utilizing AESOP is not as economical as required for running large numbers of cases. Consequently a short-cut outer optimization has been developed. The outer optimization is reduced to a one dimensional search in the following manner. First Red weapon/target values are adjusted downward and the Blue weapon/target values are adjusted upward by prescribed formulas. A total value (in terms of adjusted values) to be expended in the Red strike is then specified and the linear programming methodology is used to find the weapon allocations which maximize Blue value destroyed (adjusted values). The inner optimization is carried out in the standard manner using the true Red and Blue weapon/target values.

THE JOINT CHIEFS OF STAFF
WASHINGTON, D. C. 20301

15 June 1976

MEMORANDUM FOR Mr. A. H. Cordesman, Civilian Assistant to the Deputy Secretary of Defense

Subject: I.I.S.S. Conference on Improving Measures of the Balance

1. The following suggestions add to, complement, or expand upon the 1 June 1976 Joint Staff memorandum on the above subject. My comments and suggestions are not completely developed in this memo, but can be if they appear to be of interest to you. They are organized relative to the format and content of the I.I.S.S. annual reports on the Military Balance and the Strategic Survey.

2. Summary Comments. The use of graphs and charts in future I.I.S.S. publications is strongly encouraged. There is a real need for both a historical data base and historical perspective. More background information and trend projections for the future should be provided. A separate report on historical trends in measures of the balance is suggested. It would definitely help show critical changes and important trends over time. The use of simple statistical techniques (both descriptive and inferential) should be considered for future editions of the Balance.

Greater aggregation, including the addition of a new, more generalized taxonomy for weapons and forces should be given consideration. New measures suggested for future I.I.S.S. reports include those which refer to:

a. Military power projection potential.

b. Military power actually projected.

c. Aggressive/hostile behavior.

d. Regional balance, current and projected.

e. Relative vulnerabilities to strategic nuclear exchange.

f. Relative and percentage changes in the overall balance.

3. <u>Specific Comments on Format</u>:

The complex maze of statistical data/tables presented by the I.I.S.S. reports would be far more intelligible if greater use was made of graphs and charts. The September 1975 issue of <u>The Military Balance 1975-1976</u> does not contain, for example, even a single graph. This makes trend analyses or country comparisons more time consuming and difficult than necessary. The use of graphics similar to those found in a standard graphics text (e.g. <u>Handbook of Graphic Presentation</u>, by Calvin F. Schmid; The Ronald Press Co.; New York, 1954) would definitely improve the value of the reports to most readers. The use of statistical maps or three dimensional charts and graphs can be very helpful in drawing attention to significant geographic changes or trends in forces over time. Graphs can include much more than just bar or column charts. They can be rectilinear coordinate, semilogarithmic or ratio, frequency, probability, or pictorial in nature. Statistical maps, scatter diagrams and other projection techniques can similarly enhance the easy communication of otherwise confusing numeric data.

4. <u>Specific Comments on Content</u>:

More historical background information and trend projections are needed. Perhaps a separate, one-time report devoted exclusively to historical trends could best fulfill this existing void. There is a real need for a historical base and for statistical projections of the various elements which comprise "the balance." The use of a "moving year average" for a period of years could help trace the growth/decline of specific capabilities. The use of simple statistical concepts/measures, e.g., measures of central tendency ought to be encouraged for future publications.

A number of additional charts/graphs covering the greater aggregation of like weapons (e.g., tanks and tactical aircraft) should be included in the <u>Military Balance</u>.

The current division of weapons into strategic and general purpose categories is both arbitrary and unrealistic. These categories generally confuse and complicate meaningful arms balance discussions at the international level.

It is the employment of weapons relative to a country's national objectives that determines whether the weapons are considered "strategic" or "general purpose"

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per se. A weapon's potential use is thus at least as important as its basic nature in its categorization. LTC E. H. Josephson (OX 5-59003) first raised this as an issue, and can further explain his conceptual approach if requested.

It is suggested that an additional, more generalized, yet still operationally-oriented weapons/forces taxonomy be purposely designed and developed to facilitate international arms and policy negotiations. This addition would probably require a new perspective on how forces/weapons data should be organized and presented; and may even promote suggested guidelines for their interpretation. It could be developed over time to complement (not replace) the existing approach.

Other measures suggested for development/use in either type of I.I.S.S. report include:

a. A measure of the potential capability of a country to project and sustain a specific amount of military power over space and time, under various levels of resistance for each sphere (i.e., air, land, sea) of combat. This measure may seem too complex to handle or even portray. The measure can be readily quantified and operationally expressed, however, by using a country's existing force structures or by establishing realistic and representative "force packages." The USREDCOM Joint Task Force (JTF), the Soviet airborne brigade, or U.S. Marine Corps battalion landing team (BLT), are typical examples of force packages. A number of equivalent or "standardized" force packages could, of course, be substituted for each country's unique force structures. Transporting such forces over set distances and sustaining them for specific periods of time obviously impose logistics support requirements which can also be determined. It appears reasonable to use several incremental time periods (up to about 180 or more days) to express the length of time specific forces can be sustained. All of the critical elements in the power projection measure can be readily identified and easily organized into a simple numeric or incident matrix form.

b. An aggregate measure of the military power peacefully but actually projected by major countries in the previous 12 months. This measure would tend to follow the outline of the power projection measure. It could help identify

potential trouble spots, or regional areas where increased political influence or military force might be exerted. Examples might include: number of combat ship days spent steaming in the Persian Gulf; number of battalion days spent in another country (e.g., in joint exercises), etc.

c. An aggregate measure of a country's aggressive/hostile behavior during previous 12 months. This differs from the above paragraph in that it refers to the actual use of military force to achieve national/political ends. It could also contain measures covering the use or support of aggression or terrorism. The use of Cuban troops in Angola; U.S. (CIA) and Chinese involvements in Angola; etc., are typical examples of this measure.

d. Aggregate measures of the regional balance of power on a world-wide basis, including power shifts over time. Statistical maps could easily portray these measures. It would simply show force locations and their relative changes in time.

e. A measure of a country's relative vulnerability. This would be expressed in terms of the vulnerability of a country's:

(i) Large urban centers (1 million or greater population)

(ii) Civilian population (total)

(iii) Agricultural/food reserves

(iv) Key sources of raw materials

(v) War reserve stockpiles

(vi) Economy (total)

to a strategic nuclear attack involving a given number of weapons with specified capabilities (e.g., using SALT II guidelines and current capabilities/performance).

(f) A measure which focuses solely upon percentage changes (over time) in the overall strategic balance relative to:

(i) Civilian population sheltered from nuclear attack

(ii) Heavy industry sheltered from nuclear attack

(iii) War reserve stocks

(iv) Strategic forces (total)

(v) General purpose forces (total)

This measure would give a composite indication of relative instability over time. Implicit in this measure is the concept of strategic instability discussed in the current MORS literature.

5. While some of the proposed measures may seem too involved or complex to implement fully or even quickly, they could be discussed at the forthcoming conference and implemented incrementally over a period of time if deemed appropriate.

F. B. Kapper

F. B. KAPPER
Scientific & Technical Advisor

cc: COL W. M. Stokes
J-5/GD 20

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MEASURING THE STRATEGIC NUCLEAR BALANCE

BY: FRED PAYNE

1 JUNE 1976

PRESENTATION TO THE INTERNATIONAL INSTITUTE OF STRATEGIC STUDIES, 28 JUNE 1976

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MEASURING THE STRATEGIC NUCLEAR BALANCE

Fred Payne

R & D Associates

1 June 1976

SYNOPSIS

Various current static indices are discussed and their applications identified. One deficiency is that none measure effectiveness of nuclear weapons against a typical retaliatory target complex.

A new index "Equivalent Weapons" is proposed to remedy this deficiency. The useful form--"Retaliatory Equivalent Weapons"--is constructed by means of a simple "draw-down" calculation. Typical results of such a calculation are shown.

Sensitivity of the proposed index quantity to several underlying, simplifying, assumptions is discussed.

A conclusion is drawn that "Retaliatory Equivalent Weapons" has a unique utility in measuring the strategic nuclear balance.

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MEASURING THE STRATEGIC NUCLEAR BALANCE

Fred Payne

R & D Associates

1 June 1976

INDICES OF THE STRATEGIC BALANCE

Indices are traditionally and usefully employed to portray the strategic balance. Indeed, many analyses are nothing more than the presentation of one selected index. There are five or six indices that have some currency.

The basic unit of nuclear force is the delivery vehicle. It is that which may be attacked, must survive, and delivers the goods. The inventory of strategic nuclear delivery vehicles (SNDVs), i.e., missiles and bombers, is therefore an index of great importance and is the starting point for all other indices and war games.

Vehicles have payload. The index of total payload was originally proposed as a possible arms control parameter but was never adopted as such for various reasons. At the time of the proposal in the late 1950s, ballistic missiles carried single warheads, and the term "throw weight" was coined to express a ballistic missile's payload capability in a manner comparable to a bomber's "bomb load." Later complications with MIRV busses on ballistic missiles and bombers carrying short-range ASMs instead of gravity bombs have made the throw weight definition complex and of limited utility, especiall since it gives no information per se about destructive capability. It is retained for primarily historical reasons.

The purpose of strategic vehicles is, of course, to deliver nuclear bombs in some preferred fashion on assigned targets. The index parameter of yield is therefore more expressive than throw weight in that it conveys some concept of

target damage--one megaton can be related to fifty Hiroshima bombs--but not linearly, since a single one-megaton weapon will destroy not fifty but fourteen times the area of a Hiroshima bomb. The total megaton index therefore tends to overstate damage potential, a point which has been exploited by "overkill" advocates.

The number of nuclear weapons (N) carried by the SNDVs is a simple and useful index for expressing the number of targets that can be attacked. But, since it does not account for yield, it is not a measure of target damage.

The index "Equivalent Megatons" (EMT) was devised to avoid some of the problems mentioned above. The area covered by a stipulated overpressure is proportional to the 2/3 power of yield. An index which sums each weapon by its equivalent yield ($\Sigma nY^{2/3}$) suggests the total target area that can be covered by the weapons in a barrage mode. For typical values of target vulnerability, one EMT is equal to approximately 12 square miles of destroyed urban structures.

A recent index, called "lethality" or Counter-Military Potential (CMP), has been proposed to accomplish for hard target attacks what equivalent yield does for cities. This quantity is formed by dividing equivalent yield by the square of the aiming error (CEP). When properly used, CMP is a useful tool of analysis. As a general index, however, it does not include the effects of target hardness, and suffers from the unfortunate mathematical property of equaling infinity when divided by zero. Hence, a single weapon of any size, even conventional, that is delivered without aiming error, has a CMP of infinity; and if that one weapon is added to any stockpile, it will raise the index value of the stockpile to infinity without changing damage potential very much, if at all. (None of the previously mentioned indices have anything near that sensitivity to nonsensical evaluation.) The subsidiary parameter, CEP, is not really an index in the usual sense; however, the trend

of ICBM accuracy with time is interesting, although absolute values are subject to considerable uncertainty.

Figure 1 presents, in a highly condensed form, the strategic balance situation as represented by static indices. Presented is the ratio between the U.S. and Soviet totals for these six index quantities. As can be seen, by selecting only one index (i.e., weapon count) as the figure of merit, the U.S. can be made to look superior; by another (i.e., yield), the Soviets. Furthermore, all these indices show only the peacetime situation and in no way account for the force interaction that would occur in war.

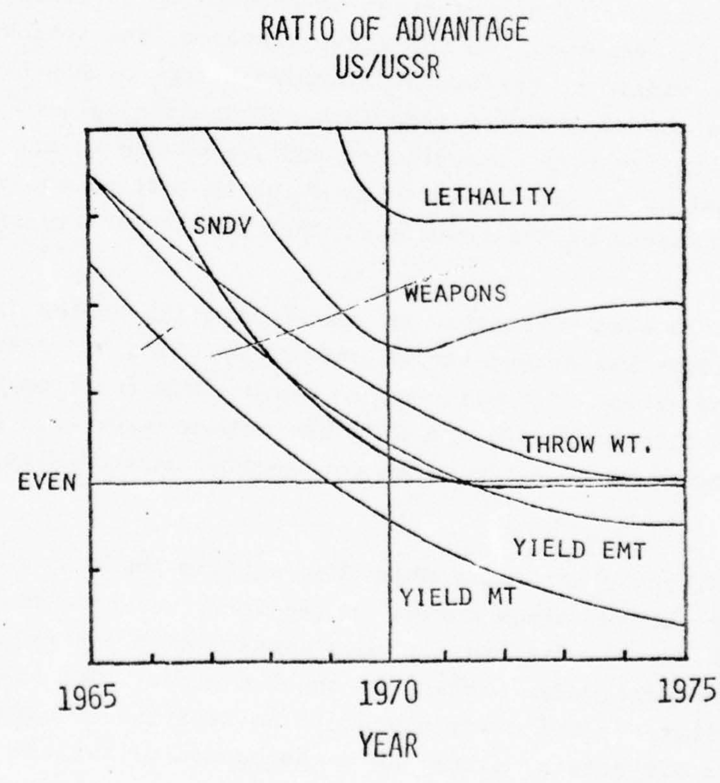

FIGURE 1

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A PROPOSED NEW INDEX

There is, of course, no historical data on nuclear wars, only speculation as to their nature. Nevertheless, war game calculations must be made and judgments based on the results. It is generally conceded that the most urgent task of a first strike would be to disarm the victim as much as possible. There may be non-military reasons for the attacker to withhold some portion of the counterforce wave, and scenarios have been imagined along these lines. Similarly, there may be reasons to continue the first attack beyond the disarming stage to accomplish civilian damage as well. However, in the first instance, the attacker allows the victim to perform a disarming attack of his own, and in the second, invites immediate retribution in kind. It is therefore both conventional and reasonable to use the residual or second-strike force which is left to the victim as a measure of the results of that particular stylized war.

It is also reasonable to assume that the Soviet Union considers its second-strike posture as being of great importance. The extent of their concern can be inferred from their efforts in silo hardening and SSBN submarines--expensive programs not needed by a nation which could count on successful preemption.

Various other approaches that utilize the comparative strength of the two sides during an imaginary war have been proposed. These calculations are very sensitive to the assumptions about the particular tactics of the two sides. For example, a real first striker certainly would be striving to ensure success in his attack, since the consequences of failure are so extremely penalizing, and he would be, by analytical standards,

lavish in the use of weapons. But beyond this, there is the extremely complex question of how to interpret any relative advantage of strategic weapons after a counterforce exchange since it involves the details of how strategic weapons could be used to enhance the chances of achieving one's objectives (for example, success in a European war). This requires that the tactical force strengths and reconnaissance capabilities of each side be brought into the evaluation. Such analyses are important, particularly as the residual forces of the attacked side grow smaller. However, they do not lend themselves easily to simple comparisons or indices.

A target system may be described functionally (military, industrial, political, etc.) or physically, in terms of its vulnerability to nuclear weapons effects. Many targets such as isolated buildings or radars are soft points. Any inventory strategic warhead can be delivered with enough accuracy to destroy these points (although for some limited options the collateral damage may be undesirable). For this type of target, only the weapon count index (N) is needed to describe the requisite retaliatory force. Other targets may be classified as soft areas. These include industrial parks, military bases or deployment areas. These targets can be destroyed by subjecting the requisite areas to a specified (e.g., 6 psi) overpressure. The index "equivalent yield" referred to a reference yield (which is usually a megaton), expresses the total required coverage for a particular area. As with point targets, the delivery accuracy is not critical. The third type of target is the hard point target. These include command posts, nuclear storage sites, dams, even some industrial targets, wherein the index parameter Counter-Military Potential (CMP) is useful as a measure. The retaliatory target system contains targets of all three types and is therefore not properly measured by any one of the above-mentioned indices.

The composition of the second-strike force depends on scenarios and on uncertain qualities of opposing forces. Since one cannot

count on any particular weapon or even any particular class of weapons surviving the first strike, the weapons of an ideal surviving delivery vehicle would optimize numbers and yield with available accuracy so as to maximize potential damage to the retaliatory target system as a whole. This concept is an idealized form of the technique of "cross-targeting," which spreads the weapons of each weapon system across each target class so that even in the worst case, all target classes are covered by some attack.

Just as we can give indices for the effectiveness of weapons against specific types of targets, so can we specify the effectiveness of a weapon against a more generalized target structure. We define this index as equivalent weapons (EW) (per weapon):

$$EW = \frac{1}{a/P_{k_1} + b/P_{k_2} + c/P_{k_3} + \ldots}$$

where a, b, c, ... are the fractions of the total target structure of different specific types of targets, and P_k is the expected kill against that type of target. In this paper only the three types of targets described above are considered (although the list could be extended to any target type). Again, these three types of targets are (a) soft points, (b) soft areas, and (c) hard points. Thus,

$$a + b + c = 1$$

$P_{k_1} = 1$ — A soft target can be killed by any inventory weapon.

$P_{k_2} = (Y/Y_o)^{2/3} = Y^{2/3}$ — When $Y_o = 1$ MT, $Y^{2/3}$ gives the P_k (expected value) against the area destroyed by a 1 MT weapon.

$$P_{k_3} = P_{k_{HPT}} = 1 - 0.5^{CMP/(H/16)^{2/3}}$$

where $CMP = Y^{2/3}/CEP^2$ and H = target hardness.

Therefore

$$EW = \frac{1}{a + b/Y^{2/3} + c/P_{k_{HPT}}} .$$

EW gives the capability of a weapon to kill with equal probability each type of target (in an infinite target set) whose proportions are given by a, b, and c. As an example, consider the case where a = 0.45, b = 0.45, and c = 0.1; i.e., the target set has 45 percent soft points, 45 percent 1-MT areas, and 10 percent hard points of 500 psi. Suppose we have 2000 weapons, each with EW = 0.5. The total number of targets that can be killed is 1000 (450 soft points, 450 soft areas, and 100 hard points).

This result can be seen in more detail as follows:

If $Y^{2/3} = 0.8$ and $P_{k_{HPT}} = 0.101$,

$$EW = \frac{1}{0.45 + 0.45/0.8 + 0.1/0.101} = 0.5.$$

TARGET TYPE	WEAPONS USED	TARGETS KILLED
SOFT POINT	450	450
SOFT AREA	560	450
HARD POINT	990	100
TOTAL	2,000	1,000

Equivalent weapons is proposed as a complex index which combines in a single measure the proper qualities of individual, simpler indices in that it relates vehicle payload to damage of a complex target system. Like all indices, it has a certain range of validity which is determined by the reality of various underlying, simplifying assumptions. These assumptions and other implications are discussed more fully later.

A comparison of the equivalent weapons (EW) in the U.S. and Soviet inventory can be made; however, a more appropriate measure is the total EW each side could deliver on the other after having sustained a counterforce strike. This total is represented by the following formula:

$$\text{Retaliatory EW} = \sum_{i}^{\text{ICBM}} N_i EW_i \rho P_S^{\text{BM ATK}} P_S^{\text{ABM}}$$

$$+ \sum_{j}^{\text{SLBM at Sea}} N_j EW_j \rho P_S^{\text{ASW}} P_S^{\text{ABM}}$$

$$+ \sum_{k}^{\text{Alert Bombers}} N_k EW_k \rho P_S^{\text{BM ATK}} P_S^{\text{PEN}}$$

where $P_S^{\text{BM ATK}}$ = probability of surviving a ballistic missile attack

P_S^{ABM} = probability of penetrating an ABM system

P_S^{ASW} = probability of surviving an ASW attack

P_S^{PEN} = probability of bomber penetration

N = number of weapons

EW = equivalent weapons

ρ = weapon reliability and other deficiencies.

Figure 2 plots the U.S. and Soviet retaliatory equivalent weapons for typical values of parameters.

EQUIVALENT WEAPONS•RETALIATORY

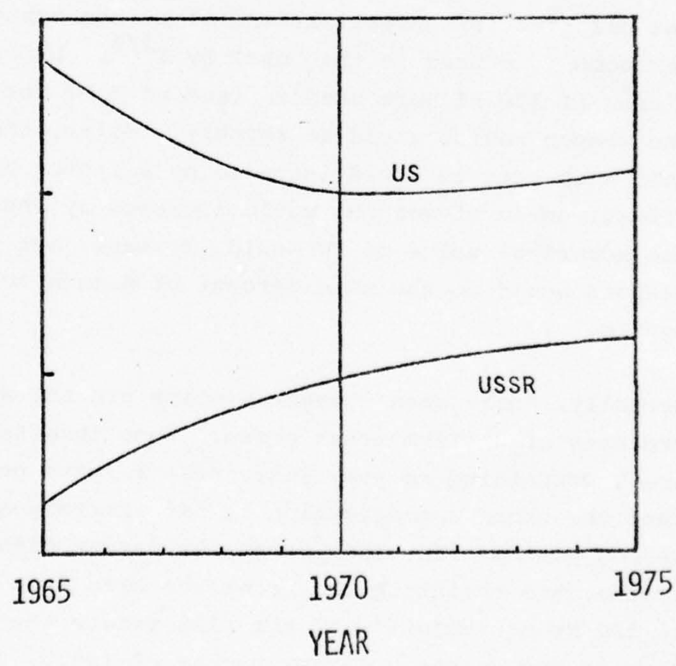

FIGURE 2

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Retaliatory EW measures the amount of damage that can be done to a specific enemy target structure. Thus, ideally, it would measure the deterrence capability of a country and could, in principle, measure the "stability" of the strategic situation by examining if both sides could retain enough forces to deter the other side from launching a first strike.

EQUIVALENT WEAPONS SENSITIVITY STUDIES

Weapon Size Scaling

The "soft area" targets denoted by the coefficient b are normalized to the area covered by a 1-MT explosion, approximately 4 miles in radius for 6 psi (which will destroy most concrete buildings). If the target system is such that urban areas as a whole are targeted, it obviously wouldn't matter what yield was selected for normalization, since the expected area killed per bomb is summed to the total by $Y^{2/3}$. Under these conditions, if 100 kT were used instead of 1 MT for normalization, the weapon radius would be roughly 2 miles, the number of soft area targets would increase by a factor of five, the effectiveness of weapons would increase by the same factor, the numerical value of EW would increase; but the same weapons would do the same percent of damage to the same target system.

Actually, "soft area" target systems are not all simply expanses of uniform urban areas. Some targets are industrial areas containing so many individual targets per square mile that the urban approximation is satisfactory at all reasonable weapon yields. In other areas the target density is much more sparse, and shrinking the reference area from 1 MT equivalent to 100 kT equivalent will actually reduce the number of area targets and create a larger number of individual, or soft

point, targets. It would require a detailed map study to determine these correction factors exactly for any one country or region, but a plausible model of an industrialized region was assumed to test sensitivity (Figure 3). In this model, reducing the reference yield from 1 MT to 100 kT decreases the number of soft areas from 2000 to 1000, and increases the number of soft points from 2000 to 7000. That the number of "soft area" targets will decrease with decreased reference yield may be visualized by considering that they must essentially disappear at, say, a kiloton and become a large number of soft points. Using this model, the values for coefficients a, b, and c change to (approximately) (0.8), (0.1) and (0.1), respectively, as opposed to (0.45), (0.45), and (0.10).

A computation was made for an exemplary retaliatory force. Using the new values of coefficients and normalized area, the percent of target coverage changed from 46 percent to 41 percent, for a decrease of 5 percent in apparent target system damage. This modest change demonstrates the insensitivity of the index REW to a rather large change in the normalizing criterion.

Optimized Attacks

The method of constructing the Equivalent Weapons Index is open to the charge of being too conservative in that, while it does give the minimum number of targets (of a fixed ratio a:b:c) that can be surely killed, it underestimates the number that could be killed if each weapon were targeted on the target type for which it is best suited. The validity of this contention depends upon assumptions about how in practice one is able to target. If it is possible to retarget completely after being attacked--in effect, writing a warplan with known forces--then it is clearly possible to do better than the assumed cross-targeting (EW) approach. If, however, one is

EXEMPLARY TARGET DISTRIBUTION

3 OR MORE POINT TARGETS/AIMPOINT = SOFT AREA

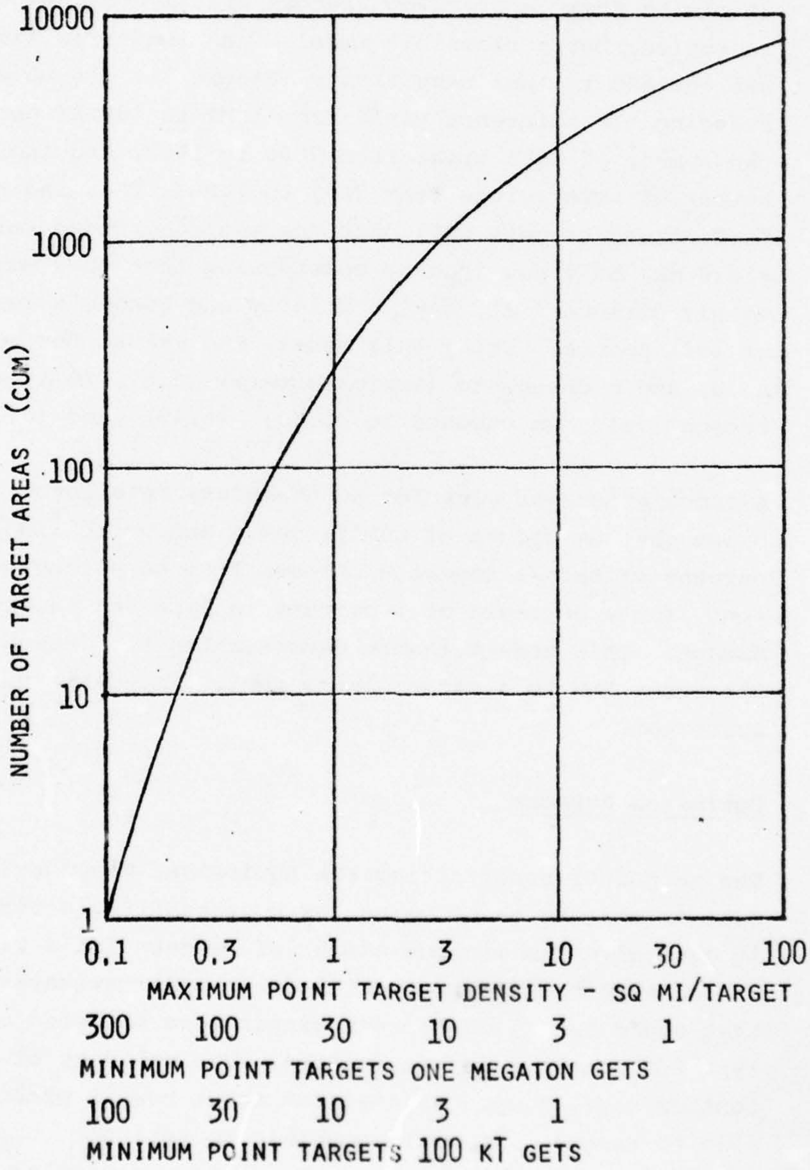

FIGURE 3

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limited to an "optimum" pre-attack targeting, the result could be better than EW or it could be worse. To illustrate these points, consider the following examples.

Complete Retargeting

Suppose there are two target types I and II, considered to be of equal importance, and we have two surviving weapon types with the following P_ks and EW:

WEAPON	P_kI	P_kII	EW
A	0.75	0.25	0.375
B	0.25	0.75	0.375

$$\text{where EW} = \frac{1}{0.5/0.25 + 0.5/0.75} = 0.375$$

If targeting is done completely by the cross-targeting principle, each 1000 surviving weapons that arrive on target will result in 375 targets being killed. If, after absorbing an attack we can completely retarget to obtain an optimum retaliatory attack, the number of targets killed could double if A and B survive in equal proportions. Figure 4 illustrates the amount of improvement as function of the mix of A and B surviving.

In actuality, it is not likely that the forces will survive in the optimum configuration, and it is therefore not likely that there will be the maximum possible improvement in targets killed.

Optimum Pre-Targeting

If the forces are pre-targeted on their optimum targets, that is, all A against target I and all B against target II, and

COMPLETE RETARGETING

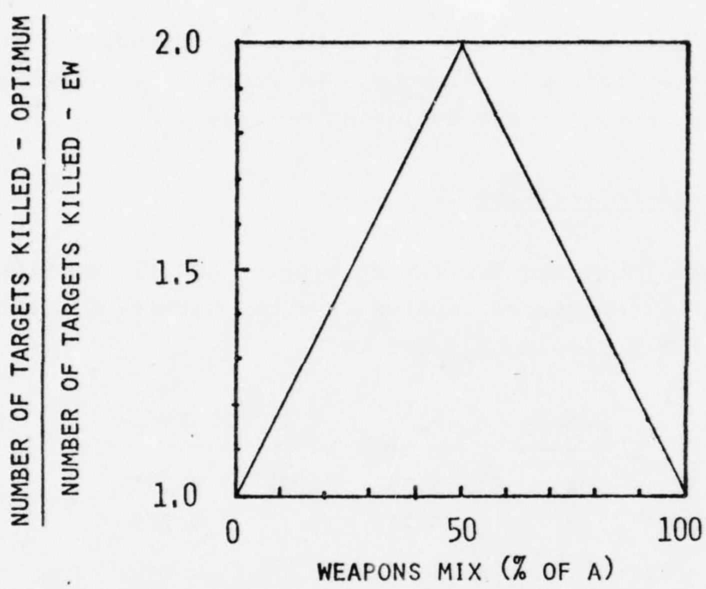

FIGURE 4

OPTIMUM PRE-TARGETING

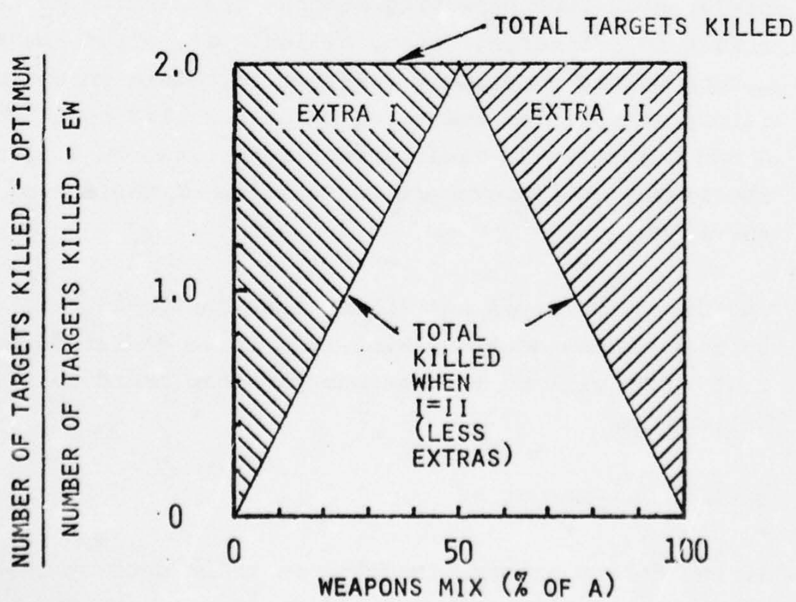

FIGURE 5

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and there is no retargeting, then a more complex situation exists as illustrated in Figure 5.

No matter what the mix of A and B surviving, there will always be twice as many targets killed (750 for the case of a 1000 surviving weapons) as when targeted by EW. However, the 50-50 mix of target types I and II killed no longer applies except when A and B are equally survivable. The solid lines indicate the totals killed under the criterion of $a = b = 0.5$ (i.e., credit is taken only for equal numbers of I and II). The cross-hatched areas indicate the extra numbers of I or II killed above this criterion.

In the region between 25 and 75 percent surviving A, one can clearly do better than EW and still maintain the equal kill criterion. However, in the regions 0 to 25 percent and 75 to 100 percent the equal kill criterion is less than that obtained by EW (and is, in fact, not met at all when only one weapon type survives), although the total number of targets killed is still twice as great.

So-called "optimum" pre-targeting has the problem that unless one can be certain of which forces will survive, it is possible that certain target types will be greatly undertargeted in proportion to their actual importance. While it is probably true that there is some tradeoff against an increase in the kill of one type vs the decrease in the other type, it is not possible at this point to quantify this tradeoff. Thus, we cannot establish whether "optimum" pre-targeting compensates enough by killing extra targets in some classes to consider that type of targeting to be more appropriate than the "conservative" EW approach.

Discussion

Equivalent weapons is an index, not surrogate guidance to targeting staffs. It is clear that under certain operational assumptions (complete retargeting and pre-targeting with the "right" mix of forces surviving), one can do better than the conservative EW approach. However, it also seems clear that these other targeting approaches do not lead to a quantifiable index which relates vehicle payload to target damage. Both cases greatly depend on which weapons actually survive (which equivalent weapons does not) and, in the case of pre-targeting, there is no present way to arrive at an index formulation which properly reflects the tradeoff between a failure to kill one target class to an appropriate level vs overkilling other classes.

Survivable Force Size Scaling

The EW index is computed on the basis of an infinite target set of equal value within each target class, so that whatever target happens to be assigned to a surviving weapon is as good as any other target in that class. This assumption disregards the fact that small attacks which concentrate on high value targets will do more scored damage than EW predicts.

Assume a target set with the most valuable target having a value of 100, the next most valuable 1 percent less, or 99, the next 98, etc. Figure 6. Let us assume a force of 100 weapons with a delivered P_k of 100 percent against all targets, but targeted on the assumption that only a unidentified 10 percent of the force will survive an attack. The target laydown proceeds as follows: the first weapon, which has a survival expectation of only 10 percent, goes on the first target and reduces the expected value of the first target to 90, making it numerically nearly equal to the eleventh target. The second weapon on the second target reduces its

value to nearly that of the twelfth. This process continues for ten weapons, at which point there will be two targets of nearly equal value for rank 11th through 20th respectively, remembering the discounted value of the first ten. Continuing, there are three targets of nearly equal value for rank 21st through 30th targets and four thereafter. The 100 weapons are used up (four weapons on each of the first ten targets, three on each of next ten, two on each of the next ten, and one on each of last ten) by the 40th target, which has a value of 67. On the average, 9.05 targets are destroyed (some are attacked which have already been destroyed), and the expected target damage is <u>785 points</u>. If, by chance, 50 percent of the force survived but was not retargeted, 30 targets would be destroyed for total value of <u>2603 points.</u>

Let us compare this result with a laydown of <u>100 weapons</u> based on the assumption that 50 percent of the force survives. The first weapon reduces the expected value of the first target to 50, making it equal to the 70th target. The first 69 weapons therefore go to fresh targets and the next 31 go on alternately to fresh and old targets down to target number 85. If 50 percent of the force does survive, 46 targets will be destroyed and the total target count will be <u>3204 points.</u> On the other hand, if only 10 percent survive, the total will be <u>695 points</u> instead of the 785 which was gained by the 10 percent laydown. Table 1 portrays these results. It shows that targeting for the "expected value" of survival is clearly best in the region of that value (a versus b, and c versus d) and that getting a high chance of killing a few targets is obtained at the expense of poor performance against many targets (d versus c).

EXEMPLARY TARGET SET

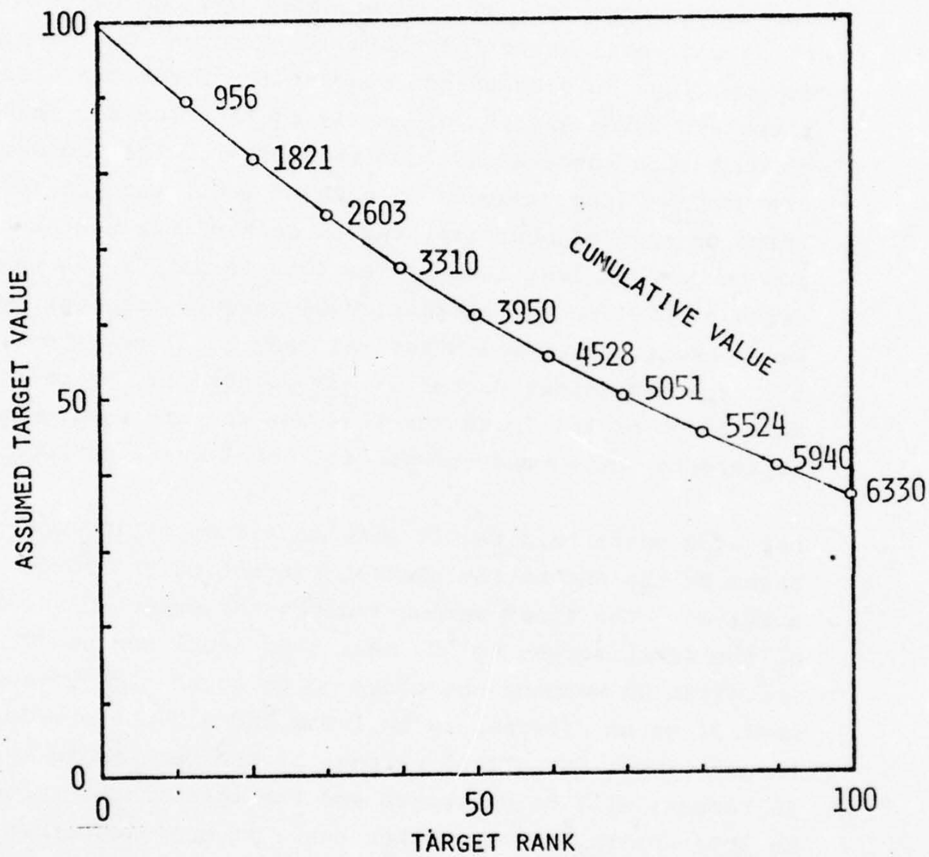


FIGURE 6

SURVIVABLE FORCE SIZE SCALING SUMMARY

	ASSUMED TARGETING SURVIVAL	ACTUAL SURVIVAL	TOTAL TARGET VALUE
A.	10%	10%	785
B.	50%	20%	695
C.	50%	50%	3204
D.	10%	50%	2603

TABLE 1

Summary of REW Sensitivity Studies

Three possible effects on the suitability of REW as an index have been studied: (1) choice of area normalizing yield, (2) optimized versus cross-targeting, and (3) influences of target value and assumed survival level. The choice of normalizing yield was shown to be a weak effect which can be disregarded for index definition purposes. Optimized targeting wherein accurate surviving weapons are, somehow, preferentially placed on hard targets, large weapons on soft areas, and small weapons on point targets produces approximately a 50 percent improvement effect if done optimally for existing mixes of weapons, and might be a 25 percent effect for the real case without complete post-attack retargeting. This factor could be applied as a blanket rate-up of REW (if it were to be generally accepted as an index) and if it is desired to get a little closer correspondence between REW and probable target count.

The question as to whether EW understates target damage for low values of EW because of the high value of the high-listed targets hinges on whether there is assumed to be an accurate guess on how many (rather than which) forces survive. This effect is not a large one--on the order of 25 percent--but whether such credit should be taken let alone whether targeting should be done on an assumption of low force survivability, depends on the details of some attack strategy. For some strategies, credit should be taken; for other plausible ones, not. Since the effect is small, it doesn't matter much whether it is applied or not. Considerations of simplicity in index definitions would argue against its inclusion.

27 May 1976

WORKSHOP ON IMPROVED MEASURES OF THE MILITARY STRATEGIC FORCES

AGENDA

Additional Topic for Consideration

- Strategic Defense

Prepared by:

Col W. M. Stokes, USA
Strategy Division, J-5
Ext 71660

Appendix A

26 May 1976

Past and Future Trends in the Strategic Balance

Comments provided herein are based on the "Military Balance 1975-1976" compiled by the International Institute for Strategic Studies.

- The presentation of a quantative evaluation of military power and defense expenditures correctly displays raw data so that the reader can apply whatever judgments he considers appropriate to his purposes.

- In addition to a detailed listing of forces, and some summary comments, a visual display of static profiles of aggregate forces and like sub-sets (e.g., ICBMs, SLBMs, etc.) can be useful. While static profiles provide an incomplete measure of relative military capability, they are useful in addressing common perceptions of parity. See attachment for illustrative static profiles of aggregate and sub-set data. US and USSR data is displayed, however, it could well be NATO and Warsaw Pact.

- In the absence of hard information on future force plans, the extrapolation of trends and/or momentum accented by the profiles may be useful for reader assessments of future force projections, capabilities, and attendant strategies.

Appendix B

- The summary remarks on strategic forces (beginning page 3, The Balance) could (without prejudicing the data) profitably highlight appropriate milestones, trends or momentum from the static profiles.

1 Attachment
Illustrative Static Profiles

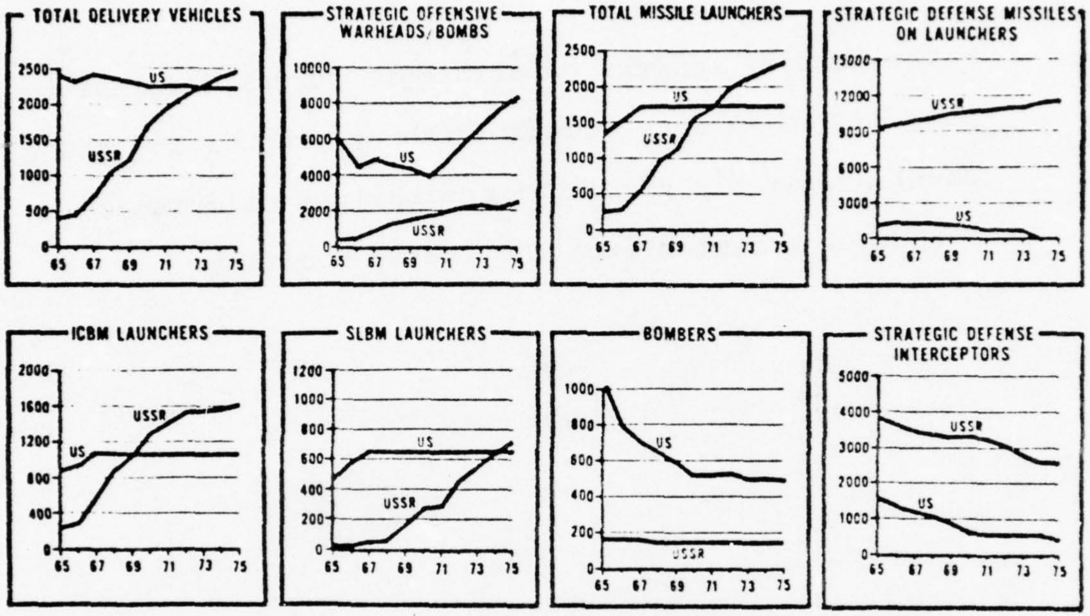
Prepared by:

Col Charles E. Hopkins, USAF
Force Planning and Programming Division (J-5)
X 77252

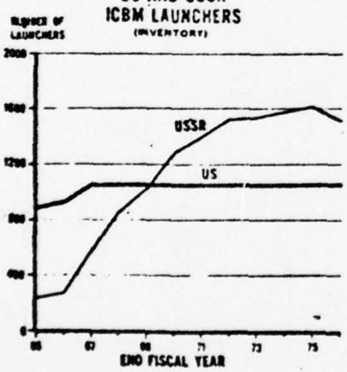
ILLUSTRATIVE STATIC PROFILES

HISTORICAL FACTORS (1965-1975)

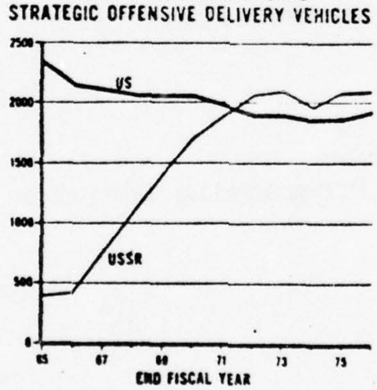
(END OF FISCAL YEAR)



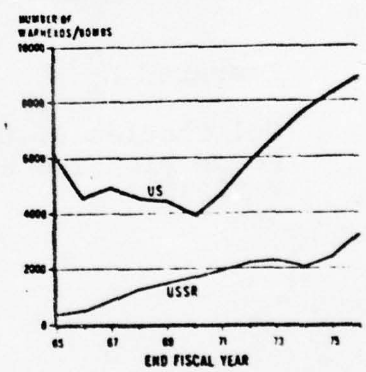
US AND USSR ICBM LAUNCHERS (INVENTORY)



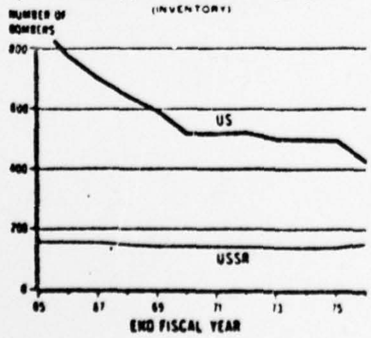
US AND USSR OPERATIONAL STRATEGIC OFFENSIVE DELIVERY VEHICLES



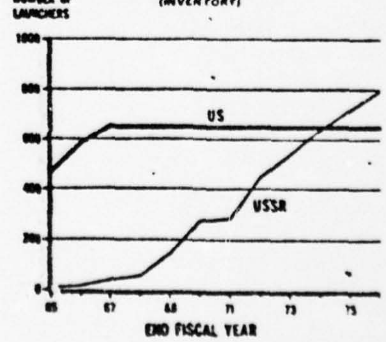
US AND USSR OPERATIONAL STRATEGIC OFFENSIVE WARHEADS, BOMBS



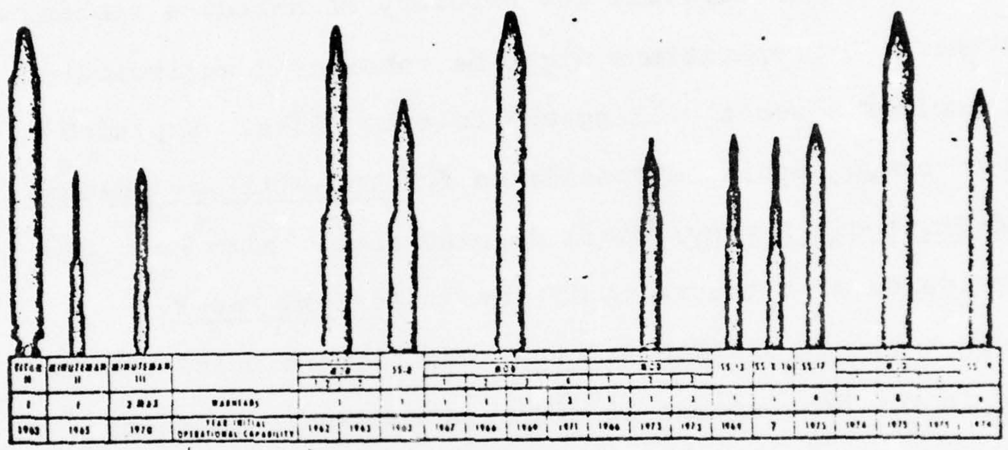
US AND USSR INTERCONTINENTAL BOMBERS (INVENTORY)



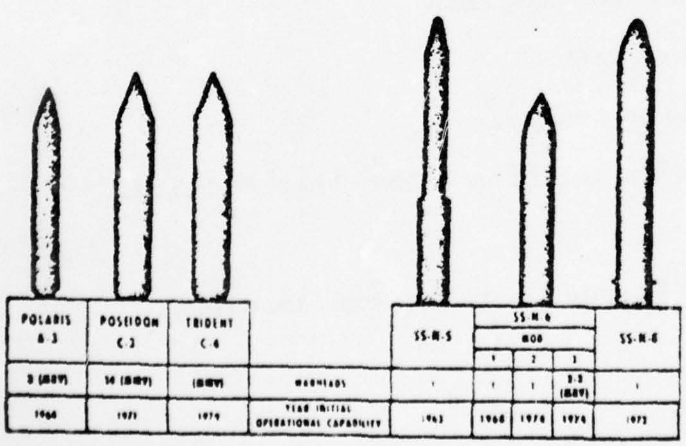
US AND USSR SLBM LAUNCHERS (INVENTORY)



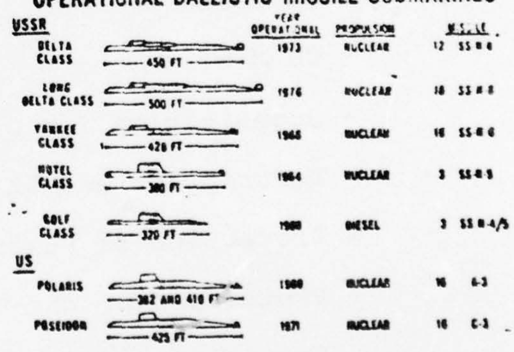
COMPARISON OF US AND USSR ICBMs



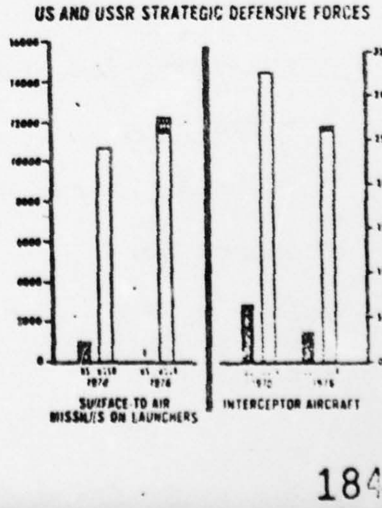
COMPARISON OF US AND USSR SLBMs



OPERATIONAL BALLISTIC MISSILE SUBMARINES



US AND USSR STRATEGIC DEFENSIVE FORCES



27 May 1976

CIVIL DEFENSE

1. General. In the event of nuclear warfare, civil defense (CD) preparedness would play an important role in the national survival and recovery of affected states. Further, CD preparations might be considered an indicator of nuclear power's willingness to take risks. Expanded CD coverage should be considered for *The Military Balance* and *Strategic Survey*; civil defense should also be considered as a future topic for an *Adelphi Paper*.

2. CD Analyses and Comparisons. The factors below should aid in the development of displays and analyses which compare CD systems and relate their contributions to the overall strategic balance:

- CD Role
- CD Mission
- Organization for Civil Defense
- Description and Status of CD Programs
- Protection of Human Resources
- Protection of War-making Potential
- Protection of Economic Capabilities other than Critical War-making Industry.
- Warning and Post-strike Rescue, Repair, and Recovery.
- Training
- Strengths and Weaknesses

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Appendix C

27 May 1976

LIMITED NUCLEAR OPTIONS

The factors below could be used in the development of approaches to compare states' capabilities to execute limited nuclear options (LNOs):

- Identification of state
- Nuclear capability
  -- Delivery systems, yields, ranges, stockpiles, etc.
- Nonnuclear projection capabilities for follow-up.
- Command and control
- Escalation control
- Conditions under which LNOs might be employed
- Possible targets
- Impacts
  -- Military
  -- Political
  -- Arms control

Appendix D

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MEASURING THE STRATEGIC BALANCE. WORKING PAPERS FOR THE INTERNA--ETC(U)
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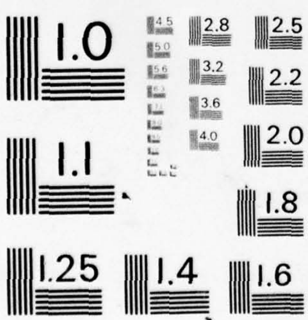

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

27 May 1976

LIMITED NUCLEAR OPTIONS

The factors below could be used in the development of approaches to compare states' capabilities to execute limited nuclear options (LNOs):

- Identification of state
- Nuclear capability
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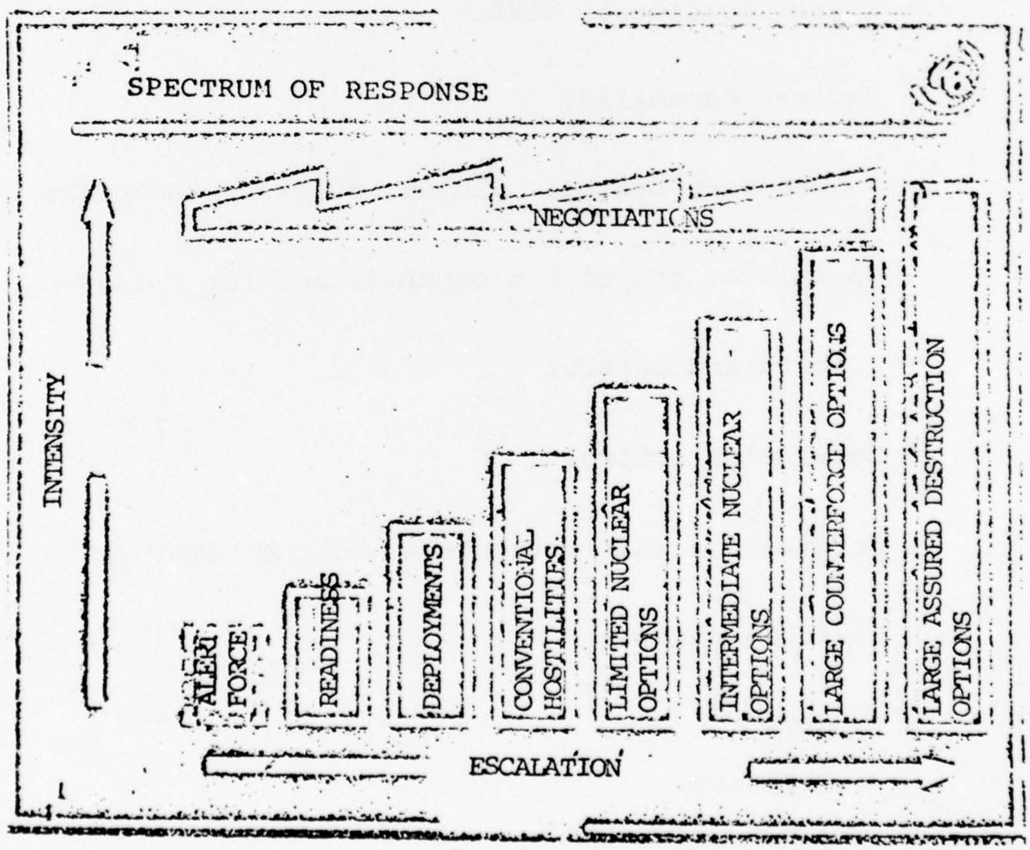
- Escalation control
- Conditions under which LNOs might be employed
- Possible targets
- Impacts
  - -- Military
  - -- Political
  - -- Arms control

Appendix D

- National policy on nuclear weapon use
- Military doctrine

In addition a comparison of States' capabilities to deter attack and engage in hostilities across the spectrum of potential military actions could be made by evaluating relative capabilities in each of the response categories displayed below.



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R-1314-PR
December 1973

Countermilitary Potential: A Measure of Strategic Offensive Force Capability (U)

W. A. Barbieri

A Report prepared for

UNITED STATES AIR FORCE PROJECT RAND

Rand
SANTA MONICA, CA. 90406

I. INTRODUCTION

Countermilitary. Potential (CMP), the measure of capability presented in this report, estimates the ability of a nuclear weapon to damage a fixed point target. The CMP of a weapon is a combined index of the explosive power of the weapon and the expected delivery accuracy. The CMP ratings for individual bomber and missile weapons in an offensive force can be added to obtain an aggregate measure of offensive-force effectiveness against point targets.

Other aggregate measures of force are available, such as the number of strategic delivery vehicles (bombers, ICBMs, SLBMs), the number of separately deliverable weapons, and the total weight of payload. The totals obtained by adding such quantities for a force are, however, difficult to interpret. Whereas a larger number indicates more strategic power in a general way, one cannot meaningfully add the number of small ICBM boosters to the number of large boosters, or add older bombers to new bombers. These quantitative measures do not include corrections for obvious and important differences in the weapons systems. An important property of a measure of effectiveness is that it take into account such qualitative differences.

Although the Equivalent Megatonnage (EMT) measure can rate a force in equivalent numbers of one-megaton weapons and although it provides adjustment for different weapon yields, it is a reliable indicator of effectiveness only against area targets.

CMP METHODOLOGY

How CMP is derived and how it can be used to analyze offensive forces and target systems is explained in this report. The following three sections develop the methodology. In Sec. II, the CMP measure is defined for weapons that are aimed at point targets rated according to the DIA physical vulnerability prediction system. Compounding damage probabilities is shown to be equivalent to adding weapon CMPs. Section III introduces the concept of total-force CMP as the sum of the individual weapon CMPs. The Point-Target Potential (PTP) of a

single target is defined in terms of hardness and desired damage probability. PTPs of individual targets can also be added to give a target system PTP. Using both measures, one can calculate the highest uniform damage that a mixed force can obtain against a mixed target system in an all-out attack. Section IV describes methods of adjusting calculations for scenario-specific planning factors such as reliability and in-flight attrition of weapons. Sections V, VI, and VII contain an extended application of the methodology. The example involves U.S. Triad forces and a scenario of protracted strategic conflict. Selected Soviet target lists are evaluated and compared with capabilities of U.S. offensive forces.

Appendix A discusses the Vulnerability Number system and nominal hardness in some detail, and Appendix B describes a method of selecting forces to be withheld for deterrance of unrestrained urban-industrial attack.

CMP provides a rough yardstick of the capability of a force to destroy point targets. Since analysis of many strategic issues involves making such assessments, the methodology has potential applications to a broad class of problems. It could be used in comparing (1) the capabilities of alternative U.S. forces against point targets, (2) the capability of a given force against alternative target systems, or (3) U.S. force capabilities with those of our adversaries. The CMP methodology can be used to trace force capabilities through complicated multistage scenarios. Damage to military targets can be estimated without developing the details of each individual sortie.

COMPARISON WITH EMT

Weapon capabilities against area targets (typically, an urban-industrial center) have commonly been described in terms of one-megaton equivalents. If delivery accuracy is adequate to place a weapon within the boundary of the area target, the important difference in comparing weapons is the overpressure radius generated by each. Dissimilar yields are compared by using an appropriate yield-scaling factor. For weapon yields in excess of one megaton, the lethal area would exceed the size of all but the largest target areas, and hence a lower scaling exponent

is commonly used for the larger-yield weapons. Total-force EMT is calculated from the number and yield of each type of weapon; delivery accuracies do not enter into the calculation. Although the EMT measure is approximate, its validity as a surrogate for the ability to damage soft area targets is generally accepted. The measure has been used frequently in strategic analytical studies for the past ten years.

Targets associated with military capabilities are usually point, rather than area, targets. Their characteristic dimensions are small in relation to the lethal radii of nuclear weapons. The hardness rating of a military point target might vary from a few psi for a radar antenna to a few thousand psi for an underground bunker. Yield and accuracy must be considered in combination to derive a meaningful indicator of effectiveness against point targets; CMP includes both factors.

There is no theoretical basis for calculating the CMP rating of a weapon from its EMT rating alone. A high EMT rating does not necessarily imply a high CMP rating for the same weapon; rather, the two measures are distinct and complementary. Every weapon has both an EMT and a CMP rating. Should a given weapon be allocated against an area target, its EMT rating is relevant. Should the weapon be allocated against a point target, its CMP rating should be the relevant measure of its capability.

LIMITATIONS OF CMP ANALYSIS

CMP is useful for calculating *approximate* damage to a point target. The standard method of evaluating damage probability against such targets gives more precise results because a more complicated calculation is made. Unavoidably, the CMP methodology trades off precision for simplicity and generality. In cases where more precision is required, existing computer models can be used to supplement and refine CMP calculations.

In some respects, the methodological development to date has been influenced by the range of parameter values that were appropriate for our applications. In extending the method to other applications, consideration must be taken of damage mechanisms against targets, precision in determining damage probability, range of yield and CEP parameters,

whether target systems are mixed or contain a few special categories, and whether it is desirable to overestimate or underestimate damage probability. Other aspects of the methodology, such as reliability effects, are mathematically derived and can be directly carried over to analyze different situations involving attack capability against point targets.

II. DAMAGE TO A POINT TARGET

In this section, the CMP of a single weapon is defined and the additive property of weapon CMPs is derived.

SINGLE-WEAPON CMP

The blast wave generated by a nuclear explosion can damage a target through overpressure and dynamic pressure[1] (both expressed in psi). A critical value of either is referred to as the target hardness. A standard expression for damage probability is[2]

$$PD = 1 - (1/2)^{(WR/CEP)^2} , \qquad (1)$$

where PD = target damage probability,
WR = weapon radius,
CEP = circular error probable of weapon delivery.

Weapon radius in turn depends on target hardness and yield. It can be expressed approximately by a product of a function of nominal hardness (H) and yield (Y) as follows:

$$WR^2 \approx f(H) \cdot Y^{2a} , \qquad (2)$$

where f(H) is a function of nominal hardness over a specified range of weapon yields, and a is a yield-scaling exponent. By substituting Eq. (2) in Eq. (1) we get

$$PD \approx 1 - (1/2)^{f(H) \cdot Y^{2a}/CEP^2} . \qquad (3)$$

We define the weapon-related factors in this equation as the Countermilitary Potential (CMP)

$$\boxed{CMP = \frac{Y^{2a}}{CEP^2}} . \qquad (4)$$

Convenient units are yield in megatons and CEP in thousands of feet, so that one megaton delivered with a CEP of 1000 feet is one unit of CMP.*

The weapon radius scales as the 0.33 power of yield for a fixed overpressure level. For targets which have the same critical hardness against all weapon yields, 0.33 is the correct scaling exponent for all yields in calculating CMP. However, in the case of lower-yield weapons and hard targets, use of 0.33 scaling for yield leads to consistent overestimation of PD, and thus the scaling was changed to 0.4 for weapons of less than 0.2 MT. As discussed in Appendix A, this change ensures that a given amount of CMP will provide a minimum amount of damage probability over a wide range of weapon yields.

$$\boxed{\begin{array}{ll} a = 1/3 & Y \geq 0.2 \text{ MT} \\ a = 0.4 & Y < 0.2 \text{ MT} \end{array}} \quad . \qquad (5)$$

MULTIPLE-WEAPON CALCULATIONS

Suppose n weapons are allocated against the *same* target. Equation (3) can be used to estimate the probability of damage to the target from the i^{th} weapon, which has a Countermilitary Potential of CMP_i

$$PD_i = 1 - (1/2)^{f(H) \cdot CMP_i} . \qquad (6)$$

The total target damage probability (D) can be calculated from the usual independent-event probability model, if reliability is equal to one.

---

*A small change in CEP can have an appreciable effect in calculating CMP, since the CEP is squared. Also, estimates of bias are available for some weapons systems. Reference 3 gives a simple analytic correction which may be applied if bias values are less than one standard deviation of a circular normal distribution (σ). The correction gives an equivalent CEP. If b is the magnitude of bias, then

$$CEP \approx \sigma(\ln 4)^{1/2} \left[1 + \frac{(b/\sigma)^2}{2}\right]^{1/2} ,$$

which reduces to the exact expression for CEP when b = 0.

$$D = 1 - \prod_{i=1}^{n} (1 - PD_i) \ . \qquad (7)$$

Substituting the above,

$$D = 1 - (1/2)^{f(H) \cdot \sum_{i=1}^{n} CMP_i} \ . \qquad (8)$$

Thus, the damage to the target from n weapons is a function of the sum of the weapon CMPs. And, under this set of assumptions (hardness is a known constant and each weapon delivery is an independent event),[*] the functional form is the same as for the single-weapon damage probability.

Damage to a point target can thus be estimated from total CMP applied. It makes no difference whether the CMP consists of a single high-quality weapon or n less capable weapons.[†] We can add CMPs of multiple weapons having different yield and CEP combinations. The additivity of the CMP measure is useful in finding equivalent combinations of weapons and leads to a meaningful aggregation of total force capability.

NOMINAL HARDNESS

A target is normally assigned a P or Q vulnerability number (VN) according to the methodology of the DIA Physical Vulnerability prediction system. We briefly describe how each VN is assigned a value of nominal hardness, and refer the reader to Appendix A for details of the development.

---

[*] It is possible to make an assumption about the effect of n weapons that differs from the independent-event probability model. It is argued(4) that the independent-event model does not apply when more than one weapon is used against a target for which the hardness is represented by a probability distribution. However, even in this case, the damage probability is a function of the sum of the CMPs of the weapons applied.

[†] PD is damage probability from one weapon. D is damage probability from one or n weapons and equals PD in the special case of one weapon.

For a given VN, a plot of damage probability versus CMP results in a family of curves, one for each value of weapon yield. The approximation of Eq. (3) replaces this family of curves with a single line which has its best accuracy at some reference value of damage probability. The hardness function f(H) is of the form

$$f(H) = (bH^c)^2 , \qquad (9)$$

where b and c are constants and H is the nominal target hardness in psi. For P targets, b = 20 and c = -0.375. For Q targets, b = 14 and c = -0.283. Nominal hardness is calculated as follows.

1. Adjust the VN, using Y = 1 MT.
2. Using any standard technique, calculate the CEP that gives a PD at which the fit is desired, assuming a ground burst.
3. Calculate the CMP.
4. Using PD and CMP values, calculate H_1,

$$H = \left\{\frac{120 \cdot CMP}{-\log_{10}(1 - PD)}\right\}^{1.33} \qquad \text{P Targets}$$

$$H = \left\{\frac{59 \cdot CMP}{-\log_{10}(1 - PD)}\right\}^{1.77} \qquad \text{Q Targets}$$

5. Repeat steps 1 through 4 for Y = 0.2 MT and obtain H_2.
6. The nominal target hardness is the average of H_1 and H_2.

Example: Determine the nominal hardness of a 38P6 target. Use the program of Ref. 5 or Ref. 1 to find the CEPs for PD = 0.5. In step 2, CEP = 1788 ft. In step 3, CMP = 0.312. In step 4, H_1 = 615 psi. In step 5, CEP = 986 ft, CMP = 0.353, and H_2 = 740 psi. In step 6, H = 678 psi.

In cases where the nominal hardness is known, the hardness function can be calculated directly from Eq. (9). The complete relationship between damage probability and CMP can now be stated

$$D = 1 - (1/2)^{(bH^c)^2 \cdot CMP} . \qquad (10)$$

III. MIXED FORCE AND TARGET SYSTEM

The previous section showed how Countermilitary Potential can be used to estimate target damage probability when one or several weapons are used against a *single* target. Here we consider how CMP can be used to measure the capability of an offensive force, how targets of different hardness can be rated in comparable units, and how the damage probability associated with a mixed force and target system can be determined from aggregate measures.

OFFENSIVE-FORCE CMP

The CMP of any weapon is defined in terms of its yield and the accuracy with which it can be expected to be delivered. The CMP of a total force is

$$CMP = \sum_{i=1}^{n} CMP_i = \sum_{i=1}^{n} \frac{Y_i^{2a}}{CEP_i^2}, \tag{11}$$

where i is an index for weapons and n is the total number of weapons. Figure 1 illustrates this by showing for a mixed force numbers of separately deliverable weapons on the abscissa and the CMP rating for

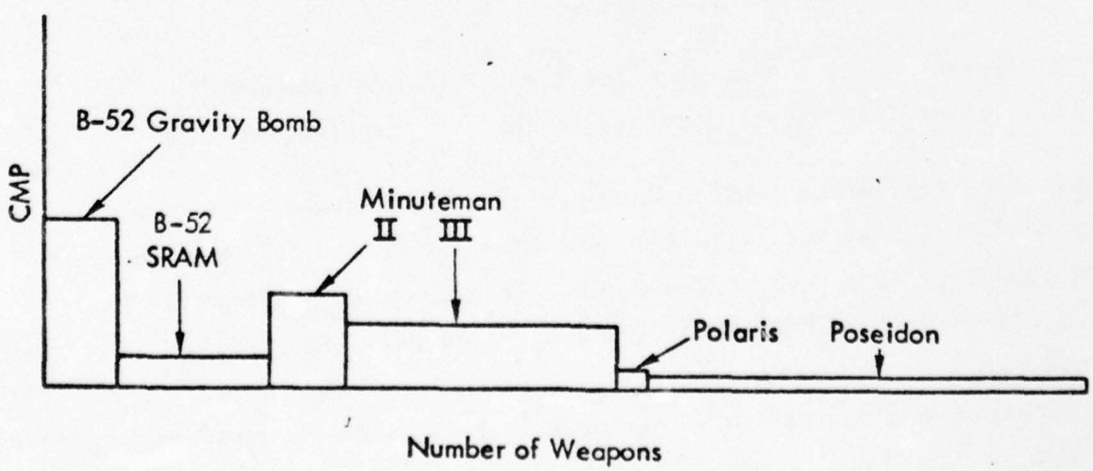

Fig. 1 — Offensive-Force CMP

each on the ordinate. Since each weapon in the offensive force is rated in CMP units, it is possible to add CMPs across the whole force to obtain the total force of CMP. This total is equal to the area under the weapons' CMP profile in Fig. 1. Depending on which rule is used to select forces, such as alert, alert plus nonalert, or surviving forces after some attack, the total force CMP would change to reflect the different numbers of weapons.

POINT-TARGET POTENTIAL

Let us define the Point-Target Potential (PTP) of a target as a measure associated with a certain damage probability and nominal hardness.*

$$PTP = \frac{-\log_2(1 - D)}{f(H)} . \qquad (12)$$

Point-Target Potential as a function of damage probability varies from zero when D is zero to infinity when D approaches one. Figure 2 shows PTP as a function of H and D for two different nominal-hardness values ($H_1 > H_2$). For a given nominal hardness there is a unique value of PTP for each value of D. For the same damage, harder targets have correspondingly higher PTP values.

Now assume that there is a mixed target array of j targets. Each target has associated with it a nominal hardness and a desired damage probability (D_j). The PTP of this target system is given by

$$PTP = \sum_j PTP_j .$$

If there are n_1 targets of hardness class H_1, n_2 targets of hardness class H_2, and so forth, and the desired damage probability is the same

*Point-Target Potential is completely equivalent to *the amount of CMP required to achieve a given probability of damage against a target of given hardness*. PTP is used in rating target systems to emphasize that what is required can be calculated without reference to specific weapons. For calculation, it may be more convenient to use $\log_2 a = \log_{10}a/\log_{10}2$.

for all targets having the same nominal hardness, then the PTP of the target system is

$$PTP = \sum_k n_k \, PTP_j \ ,$$

where k is an index for target class.

The PTP of a target system containing two different classes of targets is displayed in Fig. 3. The height of each block is determined from H_j and D_j (Fig. 2), which are assumed to be the same for each target in the class. The width of each block is proportional to the number of targets in the class. The area of each block is the PTP needed to accomplish the desired damage D_j against n_k targets of hardness H_j. The areas of the blocks can be added to give the total target-system PTP that corresponds with the assumed numbers, hardness, and damage probabilities.

DETERMINING THE DAMAGE PROBABILITY

The damage probability desired for a given target might reflect its value compared to other targets as well as its individual characteristics. The PTP of the target system would then be calculated from the set of selected damage probabilities and hardness ratings. Alternatively, damage probability can be treated as a variable. Suppose we assume that damage probability is to be the same for each target in the array, regardless of hardness rating. Then total target-system PTP is a simple function of the uniform damage probability. It has the same shape as individual target PTP versus D because it is the weighted sum of individual curves, as shown in Fig. 2. Target-system PTP varies from zero to infinity as the uniform damage probability varies from zero to one.

UNIFORM DAMAGE PROBABILITY IN ALL-OUT ATTACK

CMP and PTP are equivalent quantities, as may be seen by solving Eq. (8) for CMP and comparing the result with Eq. (12). If PTP is considered a function of D, then the damage to the j^{th} target from several weapons can be obtained by solving an equation for the damage probability of the form

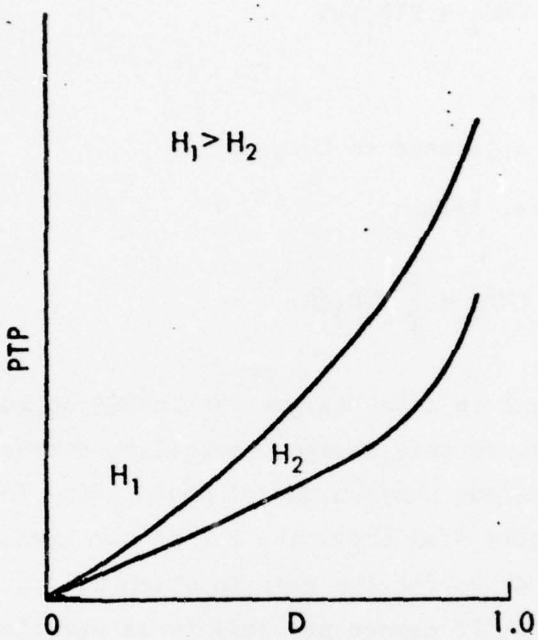

Fig. 2 — Point-target potential versus damage probability for two nominal-hardness targets ($H_1 > H_2$)

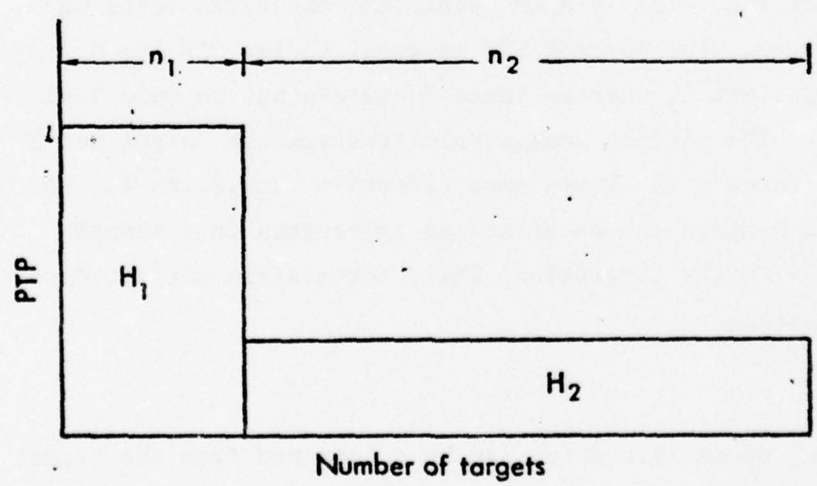

Fig. 3—Point-target potential for mixed target system when damage probability is fixed

$$\sum_i CMP_i = PTP_j(D) \ , \tag{13}$$

where j = target index, and

i = index of weapons allocated to target j.

If we sum over all j targets, then

$$\sum_j \sum_i CMP_i = \sum_j PTP_j(D) \ . \tag{14}$$

Total-force CMP is thus equal to total target-system PTP at some *uniform* damage probability. Since this damage probability corresponds to total-force CMP, *it is a maximum uniform damage probability* (D_A), *assuming an all-out attack*. Figure 4(a) shows the PTP of two hypothetical target arrays. Curve 1 is drawn for the case in which all targets have an equal damage probability. If damage probability is preselected for certain targets, the total PTP would increase as a function of damage probability against the remaining targets. The PTP for this second case (curve 2) includes a PTP value at D = 0 for those targets with a fixed requirement.

At the right of Fig. 4(a) is a CMP scale and the total force CMP ratings for two forces. For Force-X CMP is equal to the PTP for 0.78 damage against Target Set 1, whereas Force Y corresponds to only 0.45 damage probability. The uniform damage solutions against Target Set 2 are different, but Force X is always more effective than Force Y. We now examine whether weapons can be allocated to targets in a manner that is consistent with the theoretical limit for maximum uniform damage in an all-out attack.

ALLOCATION

The feasibility of an allocation can be determined from the target-system PTP profile and the offensive-force CMP profile. In Fig. 4(b), the target-system profile is drawn assuming that D is equal to the maximum uniform damage. We arbitrarily assume that there are two nominal-hardness classes of targets. The highest block represents the hardest targets, since damage probability is uniform. Figure 4(c) shows an offensive-force CMP profile, assuming three different weapon types. The

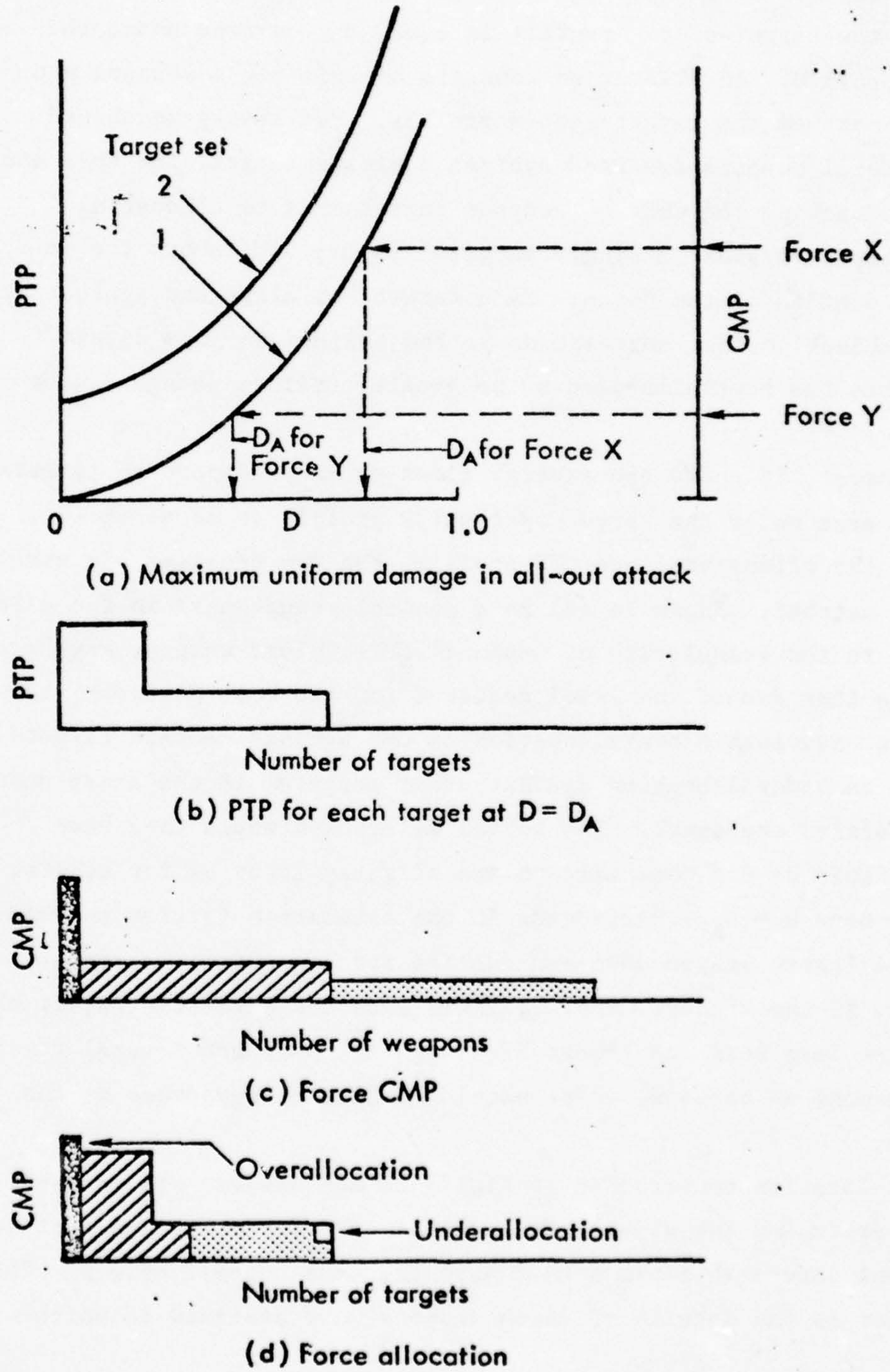

Fig. 4 — Maximum uniform damage and allocation

number of weapons is several times the number of targets, and the area under the target-system profile is equal to the area under the force-CMP profile. An allocation consists of building a weapons profile which matches the target-system profile. Previously we showed that if several weapons are used against a single target, the CMPs can be added. Stacking the CMPs of weapons corresponds to allocating multiple weapons against a single target. Figure 4(d) shows the resulting allocation of the force. Each target has allocated against it a force combination that corresponds to the maximum uniform damage. All the force has been allocated so no greater uniform damage can be achieved.

In general, if there are several times as many weapons as targets, and if the area under the target-system PTP profile is equal to the area under the offensive-force CMP profile, the two profiles can usually be closely matched. Shown in (d) is a possible raggedness in the allocation due to the granularity of weapons' CMPs. Some weapons may have CMP ratings that exceed the level required for the most demanding targets. This unavoidable overallocation of CMP against certain targets results in an underallocation against other targets, if the areas under the two profiles are equal. The actual allocation would then have slightly higher Ds for some targets and slightly lower Ds for others; most would have $D = D_A$. Raggedness in the allocation is also unavoidable if the lowest weapon CMPs exceed PTPs for the softest targets. Conversely, if the highest CMPs are lower than the highest PTPs, if the low CMPs are less than the lowest PTPs, and if there are several times as many weapons as targets, there should be little raggedness in the allocation.

The allocation constructed in Fig. 4 is not unique. It is possible, by switching the weapon blocks within the target-system profile, to represent innumerable plans that have the same overall effect. They would differ in the details of which weapons were assigned to which targets.

Countermilitary Potential is a *static* measure of force capability. The CMP required to achieve a specified damage does not change whether the targets are to be attacked rapidly, or whether they are to be

attacked over time. But some allocations may have much better performance against time-urgent targets than other allocations that meet the same damage probability criterion. If only some of the forces are to be sent against some of the targets, then as long as the uniform damage probability is not exceeded, the reserved forces would continue to threaten the same uniform damage probability against the unattacked targets.*

Weapons-system-reliability factors and methods of overcoming defenses are important practical considerations when evaluating the performance of a specific allocation. How such factors can be incorporated into CMP calculations is addressed next.

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*This assumes the reserved forces are not destroyed before they are committed.

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27 May 1976

VULNERABILITY ANALYSIS

1. General

- The strategic and military balance is complex act of dissimilar forces, dispositions and capabilities. One facet of this set which should also be considered in any measure of the balance is the relative vulnerability of each superpower's targetable resources.

- Vulnerability of not only strategic and general purpose military forces, but also of the civilian population, critical industry, food reserves and similar aspects of national wealth will be conducive to analysis.

2. Vulnerability Variables

- Some of the variables present in a vulnerability review would include dispersion, civil defense system coverage and effectiveness, hardening of industrial sites and communication centers, etc. Appropriate measures of vulnerability could be developed for each of the major variables considered, e.g., number of plants and percent of specific industry which is hardened; this could be especially revealing in such industries as aircraft or armored vehicle production, refineries and the like.

Appendix F

- Should such an analysis be attempted, an assessment of current vulnerability could be made and coupled with projections over time. Use of estimates, giving a range to allow for uncertainty, is a technique which could be examined.

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WHY PARTITION?

1. General. Historically, and for good purpose, military forces have been organized, structured, examined and compared in large part according to their projected role in general war. Forces are partitioned as strategic and general purpose, offensive and defensive, combat and support, and nuclear and conventional. The distinctions are often arbitrary and linked to those characteristics perceived as most significant to the individual or group determining the partition at the time the labels are concocted. A difficulty arises, however, when such partitions become so widely accepted that they become an intergral part of any discussion of military forces without critical examination of their utility in such discussions. For example, the two major weapons negotiations now underway appear to have been, at least initialy, conceived and proposed with the belief that there would be little difficulty in reaching agreement on the forces that would be considered in the negotiations. The Strategic Arms Limitation Talks (SALT) were to be concerned with strategic forces and the Mutual and Balanced Force Reduction (MBFR) negotiations were to address general purpose forces. The onset of actual negotiations shattered such illusions.

2. Partition Problems. SALT found the Soviet Union wanting to address Forward Based Systems (FBS) on the not illogical grounds that they constituted a threat to the Soviet homeland. The US rejected inclusion of the FBS because it considered such forces theater, or general purpose, forces which did not have a primary strategic role. More recently, the Soviet BACKFIRE and cruise missile systems of both sides have become sources of much discussion as to the appropriateness of their inclusion or exclusion from SALT and whether or not they should be counted in any final agreement. Thus, partitions that seem clear and unambiguous to one side or the other, or which seem appropriate at the time of their inception, become major stumbling blocks when new viewpoints or technology blur the previously well defined concept.

In a similar fashion, MBFR negotiations have been unable to resolve, to this point at least, the problem of force defintions. Forces that are clearly ground or air forces according to US standards are found to be not so clearly definable when considering

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Warsaw Pact, or, in some cases even NATO, organizational structures. It is no easy task to reach agreement on such matters because of the inherent political and budget considerations that are involved in the labels associated with military forces. The Warsaw Pact has little incentive to assign air defense forces, which wear different uniforms and come under a different command structure, to the ground forces for negotiating purposes because that would increase the number of forces potentially included in any reduction agreement.

Similar problems of partitioning have resulted in the exclusion of significant forces with potential strategic or general purpose applications from consideration under the umbrella of either set of negotiations or from adequate consideration in calculations of the force balace that exists. Some examples include certain naval forces, such as aircraft carriers, and MRBM and IRBM systems. The number and types of forces which have the potential for use under a variety of conditions and in several roles is likely to increase rather than decrease. Technology will provide increased ranges, improved targeting capability such that conventional weapons can successfully attack targets previously considered vulnerable only to nuclear weapons, and entirely new systems will be introduced, all of which will increase the difficulties of dealing with forces according to the current standard partitions.

3. Recommendation. It seems unlikely that abandonment of the practice of partitioning forces will be accepted, regardless of the difficulties associated with the practice. The convience of the practice clearly dominates the problems. It does seem possible, however, to expand the IISS presentations of the strategic balance and other sets of balance calculations to include a discussion of forces which defy easy catorization. Such presentations should account for the uncertainty of their role and provide an upper and lower bound estimate of the effect of their inclusion or exclusion in a particular catagory. Thus, as an example, a table or figure depicting the ICBM/SLBM forces available to both sides might also depict the MRBM/IRBM forces and a footnote explaining the impact of range limitations of the latter. Similar treatment would be accorded other forces, depending on the purpose of the presentation. There should also be an explicit discussion of such forces in any accompanying text, including the uncertainties regarding their use. In this way, each presentation provides an exhaustive evaluation of the forces and their potential. This method has been used in the past; it is not new. What is new is that it would be an integral part of all presentations rather that appearing by exception in selected cases.

THE STRATEGIC NUCLEAR BALANCE:

WHAT IT IS AND HOW TO MEASURE IT

BY

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Summary

of

The Strategic Nuclear Balance:
What It is and How to Measure It

This paper discusses a number of aspects of the strategic nuclear balance, as follows:

- The introduction explains two different perspectives on the concept of a nuclear balance.

- The section on indices for measuring strategic nuclear forces discusses four categories of indices, ranging from relatively static ones (such as inventory counts) to sophisticated war gaming activities which attempt to analyze the dynamic interactions among numerous force inputs.

- The section on indices and perceptions examines how perceptions of power enter into the establishment of a military balance.

- The section on portraying bomber forces analyzes three portrayals in the past year (those in the IISS The Military Balance, the Secretary of Defense's Posture Statement, and the Library of Congress study on the U.S./Soviet military balance), suggesting problems with each and methods of improvement.

- The section on counterforce considerations discusses force effectiveness as a function of the interaction among accuracy, weapons yield, and target vulnerability.

- The conclusions section notes the problems peculiar to dealing with a strategic nuclear balance as opposed to conventional balances, and suggests an appropriate mental image of the strategic nuclear balance.

CONTENTS

Introduction

That most perceptive of modern philosophers, the late Ludwig Wittgenstein, once noted the obsessive tendency of otherwise thoughtful men to fall victim to the forms of expression they employ. One such form of expression is the phrase 'military balance'. When we speak of a military balance, are we speaking of an event susceptible to quantitative assessment and analysis and thus reducible to numeric categories? Or, conversely, are we dealing with dimensions which invite yet ultimately cannot be contained within quantitative understanding? To deal with those questions, we can first consider the following.

The idiom of warfare has long shared a close relationship with the language of physical science. This relationship is demonstrated by the following passage from Book 3, Chapter XII of von Clausewitz's classic treatise Vom Kriege:

> War is the shock of two opposing forces in collision with each other, from which it follows as a matter of course that the stronger not only destroys the other, but carries it forward with it in its movement.[1]

Read uncritically, this passage suggests that war is nothing more than a series of clashes between opposing forces. What might this mean? From a mechanical perspective, force connotes the ability to effect change in moving masses, and forces thus contend with one another as determinants of the precise changes to be exacted. Carrying this perspective further, one finds that forces directed relative to an accepted framework can be assigned numeric values and

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summed. Movement (or, more precisely, change in movement) occurs unless opposing forces are conversely directed yet equal in magnitude. If that is the case, the forces cancel one another's influence, and if the mutual cancellation is complete, a state of non-movement or equilibrium is accordingly achieved. To the extent that the state of equilibrium shows promise of continuation, it is characterized as evidencing stability. To destroy the equilibrium, a force imbalance must be created: one force must be stronger than another. In war, this would entail, then, that "the best Strategy is _always to be very strong_, first generally and then at the decisive point."2 This, albeit superficially (and without full credit to the complexity of von Clausewitz's thought), captures the language of military strategy as _ipso facto_ an exercise in Newtonian mechanics. This provides one perspective.

There is, however, another deserving point of view. War as a human affair has, it would seem, essentially noncausal dimensions. We can summarize this by the phrase 'the psychological aspect of war'. From this perspective, war becomes a complex human institution, being partly ritual and partly circumstance but largely a matter of calculated design. Strategy thus is seen as an exercise aimed not merely at overcoming force with force, but also (and more importantly) aimed at projecting images of strength and perceptions of power, intended to upset calculated designs in anticipated yet ultimately unpredictable ways. This perspective lies behind the ancient observation of Sun Tzu that "all warfare is based on deception,"[3] More recently, it underwrites the thesis advanced by B.H. Liddell Hart:

> Strategy has not to overcome resistance, except from nature. Its purpose is to diminish the possibility of resistance, and it seeks to fulfill this purpose by exploiting the elements of movement and surprise.[4]

What, then, is the nature of the force phenomenon with which military strategy deals? Is it a primarily causal phenomenon, measurable and quantifiable? Or is it a psychological event which defeats attempts to reduce it to mathematical expression? This paper will not enter the thorny methodological debate surrounding that issue.[5] Instead, it will be suggested that by adopting a minimum paradigm to which proponents of both perspectives can agree, it is possible to discuss the concept of a military balance in an unobjectionable yet illuminating fashion.

That paradigm is the following. At the heart of any military balance are "forces" -- men, weapons, and machines -- which can be counted, measured, and otherwise quantitatively analyzed. Yet the military balance is not simply a function of forces (be they in being, programmed, or merely attainable). A balance also involves

- the attitudes taken toward what the forces can and should do;
- how (and how well) those attitudes are translated into force structuring, sizing, deployment, and doctrinal decisions;
- the extent to which such decisions can be effectively put into practice;
- how the attitudes, decisions, and resultant practices are communicated to others; and
- the perceptions others form as a result of that communication.

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What is being balanced, in short, is not simply forces but postured forces, where posturing is understood in the sense of deliberately striking a stance which bolsters one's own confidence while conveying an image (hopefully the one intended) to others. This paradigmatic concept of military balance shall now be examined by applying it in a limited fashion to one sub-category of an overall balance -- namely, that of strategic nuclear forces.

Indices for Measuring Strategic Nuclear Forces

Since the notion of balancing postured forces introduces a multi-dimensioned issue, there arises a "levels of analysis" problem not unlike that encountered in international politics: namely, the need to decide the level at which to focus one's attention.6 This section will suggest a methodological framework which lays out four levels of analysis, as portrayed in figure 1.

LEVEL I: INVENTORY COUNT

- strategic delivery vehicles
- throw weight/payload
- weapons

LEVEL II: CHARACTERISTICS IN ISOLATION

- weapons characteristics
- delivery system characteristics
- target system characteristics
- command authority characteristics
- geopolitical characteristics

LEVEL III: TARGET DAMAGE POTENTIAL

- equivalent yield
- countermilitary potential
- hard target kill capability

LEVEL IV: GAMING RESULTS

- war games
- politico-military games

Figure 1

The first level contains the simplest indices for strategic nuclear forces: namely, inventory counts of strategic delivery vehicles, throw weight/payload, and numbers of weapons. Strategic delivery vehicles can be intercontinental ballistic missiles (ICBMs), submarine launched ballistic missiles (SLBMs), or manned aircraft. Some confusion is engendered in considering whether or not a cruise missile is a strategic delivery vehicle,[7] and significantly more ambiguity arises in distinguishing strategic systems from non-strategic systems (e.g., quick reaction aircraft deployed for theater nuclear roles, less-than-intercontinental range ballistic missiles and aircraft, or carrier-based aircraft for fleet defense). In general, however, inventory counts provide fairly straightforward, discrete figures which convey a general feeling for military strength. Moreover, inventory counts have the virtue of being determinable with reasonable confidence by unilateral surveillance means; this has facilitated their use in the strategic arms limitations arena.

Simple as they are, however, inventory counts are nevertheless frequent sources of confusion, as anyone who has been involved in the business of managing inventories can attest. This arises because of the numerous inventory categories established for planning, programming, and budgeting purposes, especially with respect to strategic delivery vehicles and weapons. There can be active inventories, programmed inventories, planned inventories, and potential inventories. Even within active inventories, there can be assigned inventories of unit equipment tasked for day-to-day operations, replacement purposes,

maintenance, training, research and evaluation, and other similar functions needed to support a modern military establishment. These distinctions are not insignificant, as they determine in large part the weapons and delivery systems available for contingency use in the critical early (and perhaps the trans- and -post) stages of a nuclear war.

Similar (though somewhat less severe) problems exist with respect to the concepts of throw weight and payload--measures of deliverable nuclear power. Throw weight refers to the deliverable weight of a ballistic missile. The translation of that weight into military effects (blast, shock, thermal, radiation, and electromagnetic) is itself a function of several variables: nuclear materials used, purities thereof, weight of casing to be subtracted, and like considerations. Throw weight is thus a rough guide to deliverable power, but neither a perfect nor a direct one. This is even more the case with payload, which refers to the deliverable weight carried by an aircraft. There is, first of all, the problem of weapons mix; within a given payload, numerous combinations of weaponry -- with associated combinations of different military effects -- are available. Moreover, given the capability of many strategic offensive aircraft to carry air-to-ground missiles (AGMs) either internally or externally, there is the added problem that much of the weight of an AGM is itself not payload, in the sense of deliverable power. Thus, in measuring aircraft payload, one must be certain that only AGM 'payload' (and not total AGM weight) is counted.

These comments do not exhaust the possibilities for ambiguity within the seemingly simple categories of inventory counts. They do, however, suggest that one must approach even the simple indices with considerable caution. Assuming for a moment that inventory counts are accurate and categorized in an understandable fashion, what do they tell one? At best, they give only a rough measure of strategic power. A nation may possess, for instance, an inventory of nuclear weapons but no reliable or survivable strategic delivery vehicles. Thus in refining an understanding of a strategic nuclear balance, it is necessary to progress to the next level of analysis -- various characteristics considered in isolation.

This level involves the inputs that would largely determine the effectiveness with which military force could be applied.[10] These inputs must each be gauged in isolation from one another before they can be put together in the dynamic exchanges characteristic of levels III and IV of this structure. For that reason, they tend to be 'static' measures of military force. Five types of characteristics deserve special attention: that of weapons, their associated delivery systems, the target systems against which they are directed, command authority systems, and the international political system. Their contributions to the military balance stem from the following.

Weapons can be characterized by the deliverable power they direct at targets, the accuracy with which it is directed, and the reliability that it can be directed with when desired. Each of these characteristics is associated with numeric assessments: yield is scaled by empirical comparison with the explosive power of

trinitrotoluene (TNT), such that a nuclear weapon releasing the same explosive energy as one million tons of TNT is a one megaton (MT) weapon; accuracy is measured by circular error probable (CEP), frequently expressed in terms of nautical miles (NM);[11] and reliability is expressed in terms of percentages, indicating inductive extrapolations from empirical data which portray the confidence one can have that a weapon will perform as expected.

All of these measures are subject to error. They are reliable largely to the extent that adequate weapons testing is available; however testing may be constrained by the quality of a country's equipment and technicians, geographic realities, fiscal limitations bureaucratic politics, arms control agreements, or domestic political considerations. (Significantly, these constraints may differ considerably from one nation to another, and thus become inputs in determining a balance of forces for those nations.) The mathematical tools for arriving at the measures, such as probability theory, are not exact sciences. Finally, there may be bias errors which have gone undetected in the testing process or unanticipated problems (e.g., weapons aging effects) which may not be discussed prior to actual weapons employment. Hence, the measures of yield, accuracy, and weapons reliability are guides to the expected performance of weapons, but neither perfect nor unambiguous ones.[12]

The next set of characteristics involve the systems which deliver the weapons to designated targets. Here, the characteristics to be considered include at a minimum launch survival, rang

factors affecting penetration, and overall systems reliability. Launch survival assesses the probability of the delivery system's successfully launching in the face of enemy attack. It is a function of many variables which themselves differ from one type delivery system to another. Strategic offensive aircraft, for instance, depend upon dispersal, alert, and quick reaction to survive a surprise attack. Land-based ICBMs can be deployed in underground silos hardened to withstand designated levels of blast and shock and protected against electromagnetic pulses, or they can be deployed in various ground-or-air mobile modes. SLBMs depend for survival upon the mobility and unknown locations of their submerged submarines. It is, one must observe, misleading to discuss the survivability of any one of these elements in isolation from the others in a strategic force, since the force components afford one another mutually protective deterrent effects, by insuring that a disabling attack cannot be simultaneously mounted against all three. This consideration will be pursued at a later point in this paper.

Other intangibles also enter into the survival issue.[13] Alert postures, crew experience, operational doctrine, and certain command and control arrangements, for instance, affect survival. Once a strategic delivery system has been successfully launched, its mission is to proceed to the target assigned. Its reliability and range then become factors -- reliability as a measure of anticipated operation, and range as a measure of targets it can strike. The delivery system eventually encounters enemy area or point

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defenses, and complicated sequences of events commence. Defensive measures are taken to detect, acquire, and engage penetrating systems which themselves attempt to avoid, degrade, or destroy the defenses. Based upon experience and predicted behavior, various measures become relevant to strategic defense: e.g., the quality of a defensive system, its operational employment, and so forth. These can be mathematically modeled based upon empirical data, with probabilities of kill (P_k's) assigned to penetrator engagements.

Assume that a penetrator has successfully survived engagement by the enemy area and point defenses and is prepared to deliver its weapon upon a target. Certain target characteristics other than active defenses then become operative. Target dispersion, for instance, may have so proliferated targets as to dilute the effectiveness of the penetrating force. Civil defense efforts may protect segments of population, while target hardening increases the ability of the target to survive nuclear attack. Relative levels of these efforts become important inputs to a military balance.[14]

Two other categories of characteristics also become important. Command authorities influence offensive and defensive measures in several important ways. Their interaction with strategic forces (as measured by security and reliability of command and control arrangements) enter into the strategic balance. They authorize the release of nuclear weapons to commanders, and they exercise various controls over the population and media. Pronounced differences in operational styles, as

well as different authority relationships (especially those of totalitarian as opposed to democratic societies) all enter into the assessment of a military balance. Similarly, geopolitical characteristics influence the balance, and should be taken into account. Geographical location, alliance and adversary relationships, and accepted 'rules' of the international system become players in the game. So do such intangible factors as the momentum of arms programs and their established trends as perceived by others.

The preceding discussion has not attempted to catalogue all the factors determining a force balance; it has merely highlighted some of the more important. Moving to the next level of analysis, then, one finds an attempt to measure the dynamic interplay among certain selected factors: namely, the weapon and the target. If the inputs are organized by assuming launch, transit, and penetration survival and if the focus is then directed at the potential for damaging a selected target, two measures frequently appear in discussions of damage potential: equivalent yield, and countermilitary potential.[15]

The first measure, equivalent yield, attempts to portray the effect of a nuclear blast against "soft" area targets: e.g., urban areas, industrial parks, military bases, or deployment areas. Such targets can be severely damaged by subjecting them to a specified (e.g., 5 psi) overpressure and to the thermal effects of a nuclear blast. Equivalent yield accounts for certain blast dissipation effects (overpressure is inversely proportional to the cube of the distance from point of detonation), by scaling the yield by an appropriate exponential factor. The resulting formula for equivalent yield

is $(Y^{2/3})$, 'Y' being conventionally set to a reference yield of one megaton. When so adjusted, the measure obtained is referred to as "equivalent megatonnage" (EMT). This measure is a more accurate guide to damage potential of a nuclear weapon against a soft area target than is simple megatonnage

Not all targets are area targets, however. Specific buildings, missile silos, or other structures are point targets. By appropriate construction and protection techniques, point targets can be "hardened" against the effects of overpressure. (Protective measures against other nuclear effects such as electromagnetic pulses also are sometimes referred to by the phrase "hardening", adding to the ambiguity of the phrase.) The degree of hardening, expressed in pounds per square inch or psi, is an indication of a target's ability to withstand the effects of a nuclear attack. In attacking hard point targets, accuracy becomes an important parameter in addition to yield. Studies in nuclear effects have suggested the function $\frac{(Y^{2/3})}{(CEP^2)}$, called "lethality" (K) or "counter military potential" (CMP), as a measure of effectiveness against hard targets.

Lethality is a measure which attempts to account for blast effectiveness as a function of accuracy and yield. It thus gives a certain index of capabilities against hardened targets, but the index has definite limitations. For one thing, it would cause perfectly accurate weapons (those whose CEP = 0) to appear to have the greatest lethality or countermilitary

potential (tending toward infinity). If this were true, an explosion releasing no more energy than that released by an overheated automobile radiator yet occuring exactly on top of a hardened target would appear to be more lethal than a 20 MT explosion 50 feet from the target. That is, of course, not the case.

Moreover, lethality does not account for the type target that the explosion is directed against. Hence, it does not portray the dynamic interaction among accuracy, yield, and target vulnerability. More will be said on this later in the paper.

These three measures of target damage capability -- equivalent megatonnage, lethality, and some measure relating accuracy and yield to target vulnerability -- all represent attempts to assess the effectiveness of nuclear weapons against different kinds of targets. They are not perfect measures, however, and where their shortfalls affect interpreting the military balance, the effects should be highlighted.

The next level of indices involves gaming activities. Games, be they war games or politico-military games, represent the most elaborate attempts to measure force effectiveness by quantitative indices. A war game measuring force effectiveness involves nothing more than a set of assumptions, an algorithmic sequencing of force engagements into discrete events, and a calculation of outcomes. A politico-military game would add

diplomatic and political events to the sequence. If one's assumptions are reasonably valid, then a game can yield valuable insight into the probable outcome of interactions among forces. Any game is merely one model (among many) of reality, however, and proper interpretation of a game's outcomes thus requires judgment, especially with respect to the game's limitations.

The preceding comments have reviewed some of the salient features of force effectiveness which enter into establishing a strategic nuclear balance. As was suggested earlier, however, the existence of a balance of postured forces itself depends upon how established indices of strategic force are perceived by others. This forms the basis of the next section.

INDICES AND PERCEPTIONS

In a memorandum prepared for the Senate Subcommittee on National Security and International Operations and published on March 10, 1972, Professor Uri Ra'anan made the following observation:

> It is all too frequently overlooked that political weight, or influence, is directly proportional not so much to physical might, in absolute, objective terms, as to perceived power--a subjective factor that can be, and is, manipulated (although, of course, physical might is one of its constituent ingredients). In the case of the superpowers, this means that their relative global impact must be measured in terms of the power of each as perceived by its own decision-makers, its intelligentsia and its general public respectively, by its allies and clients, by the decision-makers, intelligentsia and general public of the rival's allies and clients, and finally, by nonaligned and neutral states and by the so-called Third World (terms which are no longer necessarily synonymous). It is this perception, whether accurate or not, that will mold the expectations and the decisions of all the parties involved and, therefore, must be regarded as the critical political factor in any given situation.[16]

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This observation is essentially correct, insofar as it argues that political influence is a factor of perceived as opposed to absolute power. Implicit within this distinction, however, is the assumption that there is such a thing as absolute power which can be clearly separated from perceptions thereof. That assumption, unnecessary to its conclusion, is misleading and perhaps wrong. Documents like The Military Balance published annually by the International Institute for Strategic Studies (IISS) or the recently published Library of Congress study on United States/Soviet Military Balance: A Frame of Reference for Congress[17] do not merely report on a military balance; they also contribute to its establishment and continuation, in the sense that how the various indices are portrayed and discussed have tremendous impact on what interpretations are given to those indices. It is these sorts of interpretations, in turn, which influence (often decisively) determinations as to how and when forces should be employed or changed. And the nuclear deterrent relationships at any point in time are basically established if intermingled perceptions exist which determine that even if one wishes to exploit nuclear force for political gain, the potential exploitation is perceived as entailing unacceptable consequences, primarily due to the forces of others, credibly available to respond to one's exploitative moves.

This succinct statement of how perceptions enter into the military balance, at least at the strategic level, is unsatisfactorily vague. Part of its vagueness derives from the nature of the subject matter. Almost everyone agrees with the

premise that perceptions affect "reality". The difficulty is to explain exactly what that statement amounts to. Following a workshop on Perceptions of the Military Balance held at Santa Monica, California, on August 26-27, 1974, Charles Wolf, Jr., drew the following conclusion:

> For my own view, I am as convinced that the subject of perceptions is important to be sensitized and alert to, as I am that it is unlikely to yield firm and stable conclusions in response to attempted empirical research. Moreover, attempted research on perceptions may entail a particular snare: it may provide a source of spurious support for special-pleading in favor of this or that system's development, deployment, or budget, that is easier to advance and harder to refute than the "advocacy" arguments sometimes made on the basis of research on the "realities" of the military balance.[18]

From this he concludes that "there are some subjects that it is important to be aware of, but not necessarily to do anything about--perceptions may be one of them.[19]

This is an unfortunate conclusion. One can sympathize with the fear that differing interpretations of perceptions can be used to support special pleading. However, if one also views perceptions as being vital to the military balance, it follows that learning as much as we can about how perceptions can be manipulated by our enemies and what we can legitimately do to counter such manipulations is crucial to ensuring that a perceived balance of forces is maintained.[20] The French neo-Thomist philosopher Jacques Maritain once commented that if one were to judge a book by the uses to which it can be put, the Bible would be the most condemned book in history.

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A similar logic would seem to drive a reluctance to do anything about perceptions because perception-arguments can be abused.

What can be said about perceptions? Opinion surveys tend to support the conclusion that relatively simple indices of nuclear strategic power (the Level I and some Level II indices) have the most significant impact upon large segments of the attentive foreign policy elite, American and non-American, both within and outside of government. This finding is not surprising, given the complexity of the issues involved in nuclear strategy. It is, moreover, supported by recent insights from decision-making theory. John Steinbruner writes, for instance:

> Perhaps the major point is that cybernetic [decision-making] theory defines the fundamental decision problem not as a matter of maximizing expected utility (or any loose approximation) but rather as a question of simplifying an incomprehensibly complex world. Because his central problem is that of achieving a workable simplification of his environment, the cybernetic decision-maker does not make probabilistic judgments and analytic evaluations of the consequences of his actions. He does not make elaborate outcome calculations at all. Rather, the cybernetic decision-maker performs a set of procedures under simulation of <u>very narrowly constrained</u> information input. The procedures do in turn affect outcomes in the environment; in cases of successfully operating cybernetic processes the consequences return information on a feedback channel. The pure cybernetic decision-maker, however, can be and often is perfectly blind to all that. He perceives only the highly specific information input and the limited procedures he performs.[21]

This observation is not only relevant to the decision-maker, but applies to the informed reader or listener following strategic issues in the public media as well. It suggests

that given the need to cope with modern complexity, men will respond by simplifying complex issues. This drive for simplicity will likely continue to exist (or, perhaps, grow). This does not entail, however, that only the simplest indices deserve attention in widely-circulated strategic publications. On the one hand, it suggests a need to frequently and recurringly caveat simple indices which might be misleading, to undertake to explain how they might mislead, and to search for equally understandable replacements. On the other, it suggests a need to make more complex indices more readily understandable, at least to the extent that their use appears reasonably credible to the intelligent reader. The strategic nuclear balance will continue to be affected by perceptions. This is a fact of life. It is to be hoped, however, that the perceptions will be as well informed as possible, at least so as to resist the crudest forms of manipulation.

Having thus far discussed the nature of a military balance, indices for assessing the strategic nuclear dimension of an overall balance, and the relationships between such indices and perceptions, it is now possible to turn to two specific issues which have posed special problems in interpreting the balance of strategic nuclear forces: namely, how bomber forces can be portrayed, and ways of assessing the balance of counterforce capabilities.

Portraying Bomber Forces

What is the best way to portray bomber forces, such that the portrayal is correct, understandable, and capable of providing an accurate perspective to the perceived strategic nuclear balance? As a basis for pursuing this question, it is useful to first consider how bomber forces have been portrayed in three recent and widely circulated publications: the U.S. Secretary of Defense's FY 1977 Annual Defense Department Report to Congress (frequently called the Posture Statement);[22] the Library of Congress study on the United States/Soviet Military Balance;[23] and The Military Balance, 1975-1976 of the IISS.[24]

The U.S. Secretary of Defense's Posture Statement was provided to Congress on January 27, 1976. It served as the official opening round in a public debate on the proposed defense budget for FY 1977, the implications of that budget for the defense authorization request for FY 1978, and the preliminary five-year defense projection for FY 1977-1981. This document is especially important as it sets the tone for the debate stretching over the subsequent several months on "how much is enough" to provide for the national security of the United States. As such, it is an important factor in influencing a wide range of perceptions on the state of the strategic nuclear balance.[25]

Bomber forces are portrayed in several ways in the FY 77 Posture Statement. At one point it depicts U.S. and USSR strategic force levels for Mid-1975 and Mid-1976 in tabular form. (see figure 2).

U.S. AND USSR STRATEGIC FORCE LEVELS

	Mid-1975		Mid-1976	
	U.S.	USSR	U.S.	USSR
Offensive				
ICBM Launchers				
Operational [1] [2]	1054	1600	1054	1500
Others	0	0	0	0
SLBM Launchers				
Operational [1] [3]	656	730	656	850
Others	0	0	0	0
Long Range Bombers [4]				
Operational [5]	497	160	421	180
Others [6]	112	170	184 [7]	175
Force Loadings [8]				
Weapons	8500	2500	8900	3500
Defensive [9]				
Air Defense				
Surveillance Radars	59	4500	61	5500
Interceptors [10]	412	2600	315	2600
SAM Launchers [11]	–	10000	–	10000
ABM Defense				
Launchers	36	64	100	64

[1] Includes on-line missile launchers as well as those in the final stages of construction, in overhaul, repair, conversion and modernization.
[2] Does not include test and training launchers, but, for the USSR, does include launchers at test ranges which are probably part of the operational force.
[3] Includes launchers on all nuclear-powered submarines and, for the Soviets, operational launchers for modern SLBMs on G-Class diesel submarines.
[4] The following long-range bombers are placed in this category: for the U.S.: B-52s, FB-111, and B-1; for the USSR: Bear, Bison, Backfire.
[5] Includes deployed, strike-configured, aircraft only.
[6] For the U.S., includes bombers for RDT&E and in reserve, mothballs and storage. For the USSR, includes all variants of Bear, Bison and Backfire (tankers, ASW, trainers, reconnaissance, etc.) wherever located.
[7] Represents the maximum number of aircraft assuming no cannibalization.
[8] Total force loadings reflect only those independently-targetable weapons associated with on-line ICBMs/SLBMs and UE aircraft. Weapons reserved for restrike and weapons on inactive status are not included.
[9] Excludes radars and launchers at test sites or outside CONUS.
[10] These numbers represent Total Active Inventory (TAI).
[11] These 10,000 launchers accommodate about 12,000 SAM interceptors. Some of the launchers have multiple rails.

Figure 2[26]

Several things are worth noting about this depiction. First, in a footnote to the tabular data, it establishes what are to be considered long range bombers: for the U.S., B-52s, FB-111s, and the B-1; for the USSR, Bear, Bison, and Backfire. The B-1 is mentioned despite the fact that it is not yet in the U.S. active strategic inventory, thus serving to alert the reader to the function that the B-1 will play and to project the reader's attention beyond the two years covered in the table.[27] The Backfire is mentioned despite Soviet protestations that it is not a "long range bomber", thus reflecting Department of Defense assessments of the role that the new Soviet bomber is capable of playing.

And second, the table distinguishes between two categories of long range bombers: "operational" and "others". This serves to delineate deployed, strike-configured aircraft from aircraft used for other purposes (bombers for research, development, test, evaluation, ASW, training, or reconnaissance activities; bombers in mothballs and storage; or Soviet bombers used as tankers). Finally, a footnote to the table observes that the numbers can change if some aircraft are "cannibalized" for parts -- a practice in which parts from one older-model aircraft are used to keep another aircraft of the same model flying, after its production line has shut down.

The figures given in the table are interpreted in at least two points in the text -- one giving a general interpretation and

one speaking specifically to bombers. The general interpretation relates strategic forces to their rationale:

> The strategic balance, as represented by presently deployed forces, is stable and acceptable today. But if the Soviets continue their present programs with the effect of upsetting the balance, we are prepared to re-establish strategic stability by force improvements of our own...We do not look forward to a further adjustment in our strategic programs; we have competing uses for our resources. Provided that we are alert and careful, the Soviets cannot obtain an influential advantage. Our preference is to limit the competition and assure strategic stability at lower levels of force. Now or later, we are prepared to work to that end with the USSR. But we intend to remain alert, careful, and competitive.[28]

The specific interpretation discusses the contribution of a bomber force to deterrence:

> Because of its significant contribution to credible, high confidence deterrence of nuclear war, we plan to continue to maintain an effective strategic bomber force. Specifically, bombers provide for a measured warning in crises, offer an essential hedge against failure in our missile forces, and complicate Soviet attack and defense planning. They also provide a visible show of resolve and constitute a flexible, multipurpose system.[29]

Before commenting on the approach of this Posture Statement to portraying bomber forces, the other two portrayals will be considered: first, the Library of Congress study and second, The Military Balance by the IISS. The Library of Congress study was requested by Senator John C. Culver, a member of the Committee on Armed Services. In his letter of transmittal to the Chairman of the Senate Armed Services Committee on January 20, 1976, Senator Culver summarized the impetus behind the study:

> At my request, the Congressional Research Service of the Library of Congress has prepared a detailed study on "The United States/Soviet Military Balance" as a frame of reference for consideration of the Defense Department budget request...I believe that this study is balanced, detailed, and thought-provoking. It has been reviewed by over 100 knowledgeable persons in the Executive and Legislative Branches. It contains the most comprehensive and current unclassified data on the relative strengths and weaknesses of the Soviet Union and the United States. It also suggests questions (rather than answers) which the Committee and the Congress might want to ask in evaluating our national security needs.[30]

The study was authored by John M. Collins, a Senior Specialist in National Defense at the Library of Congress, and his staff assistant, John Steven Chwat. The methodology they employed is worth noting. First, they claim that a bilateral military balance can be studied separate from a strategic balance (which they define to include political, economic, social, and other aspects of national power).[31] And second, they recognize that "raw statistics...are significant only in context. What each side has is less cogent that [SIC] what U.S. armed forces can do on demand, despite Soviet opposition."[32] Consequently, they proceed to compile and apply what they call "force sufficiency factors" for ascertaining "how much is enough" -- a question often asked, they note, by U.S. leaders, but (they claim) never "objectively answered".

The study is divided into two parts. The first part collects evidence on the "quantitative balance" and the "qualitative balance". The second discusses causes of asymmetries, assesses those asymmetries, appraises the present and projected balance in terms of problems, and concludes with a discussion of policy

options. In the process of developing these sections, bomber forces are portrayed in several ways. First, they add a new twist to portraying inventory data, in the sense that they group data by categories of "superiority": i.e., not all forces appear in the same tables, as separate tables are used to portray U.S. and Soviet areas of superiority and equality. A summarizing table at the start of the study depicts the areas of superiority for each (figure 3), and bomber forces then appear in the table showing U.S. quantitative superiority for active forces (figure 4).

United States/Soviet numerical balance

U.S. Superiority		Soviet Superiority	
STRATEGIC NUCLEAR			
Bombers ALCMs	MIRVs Warheads	ICBMs SLBMs	SLCMs Air defense
TACTICAL NUCLEAR			
Fighter/attack aircraft Artillery		Missiles Medium bombers	
GROUND FORCES			
Marines Helicopters	Anti-tank Weapons Logistic tail	Personnel Divisions Air defense	Tanks Artillery
NAVAL FORCES			
Aircraft carriers Aircraft afloat		Attack Submarines Cruise missile ships Combat boats Aircraft ashore Mine countermeasure ships*	
TACTICAL AIR FORCES			
		Fighter/attack Airlift	
STRATEGIC MOBILITY FORCES			
Airlift		Sealift	

Figure 3[33]

U.S. QUANTITATIVE SUPERIORITY (ACTIVE FORCES ONLY)

	United States	Soviet Union	U.S. Margin
Strategic offensive:			
MIRVed ICBM	550	110	440
MIRVed SLBM	416	0	416
ALCM	1,140	185	955
Heavy bombers [1]	463	135	328
Tankers	615	50	565
ICBM/SLBM warheads	6,794	3,442	3,352
Strategic defense: None	NA	NA	NA
Ground forces:			
Airmobile divisions	1	0	1
Infantry divisions	6	0	6
Marine divisions	3	0	3
Nuclear artillery pieces	450	0	450
Helicopters [2]	9,487	2,580	6,907
Naval forces:			
Personnel [3]	515,400	386,000	129,400
Attack carriers	14	0	14
Helicopter carriers	7	2	0
Cruisers [4]	27	13	14
Destroyers [4]	70	65	5
Nuclear-powered attack subs [4]	62	35	27
Carrier aircraft	1,508	53	1,455
Marine fighter/attack aircraft [5]	468	0	468
Mobility forces: Strategic airlift	300	60	240

[1] Excludes United States FB 111's and Soviet Backfire bombers.
[2] Helicopters include 437 in the U.S. Marine Corps.
[3] Excludes ballistic missile submarine forces.
[4] Cruisers and destroyers exclude SSM types.
[5] U.S. Air Force and Marine shore-based fighter/attack aircraft combined fail to equal Soviet counterparts (2,768 to 3,590).

Figure 4[34]

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Second, textual discussion predominates. The study begins by noting that "The quantitative military balance since 1965 has shifted substantially in favor of the Soviet Union... This country's numerical superiority in strategic nuclear weapons, which was still evident a decade ago, has dissolved."[35] It continues: "Today, the United States lags in every [strategic nuclear] category, except for MIRVed launchers and aggregate warheads. Continued U.S. ascendancy in quantities of heavy bombers and air-launched cruise missiles (ALCMs) compensates in part, but Soviet superiority in sea-launched cruise missiles (SLCMs) offsets that advantage to some extent."[36] This statement should not be interpreted in isolation from the remainder of the study. It does, however, establish the study's general tone: namely, one of concern with the pace and vigor of Soviet strategic force modernization efforts. The study returns to bombers with the conclusion: "Replacing B-52s with B-1s is the only strategic nuclear procurement/deployment plan directly related to current U.S. shortcomings."[37]

Turning to The Military Balance, 1975-1976, one finds that the U.S. and Soviet comparative strategic forces strengths are summarized in Table 1 of the document, entitled "Nuclear Delivery Vehicles: Comparative Strengths and Characteristics."[38] Two categories of bombers are listed: long-range bombers (defined as having a maximum range of 6,000+ statute miles) and medium-range bombers (defined as having a maximum range of 3,500-6,000 statute miles, and being primarily designed for

bombing missions). U.S. long-range bombers are taken to be the B-52D-F and B-52G/H, while the listed Soviet long-range bombers are the TU-95 Bear and the Mya-4 Bison. The FB-111A is listed as the sole U.S. medium-range bomber, while the Tu-16 Badger and Backfire B are given as the Soviet medium-range bombers. Concerning the Backfire, the document explains: "Backfire is classified as a medium-range bomber on the basis of reported range characteristics."[39]

An attempt is made in The Military Balance to give a general feeling for bomber effectiveness by providing three Level 2 indices: maximum range, maximum speed, and maximum weapons load. The first index is caveated by the following statement:

> Theoretical maximum range, with internal fuel only, at optimum altitude and speed. Ranges for strike aircraft assume no weapons load. Especially in the case of strike aircraft, therefore, range falls sharply for flights at higher speeds, lower altitude or with full weapons load.[40]

No attempt is made to interpret what maximum weapons load means in terms of force effectiveness.

Two additional portrayals of bomber forces in The Military Balance should be mentioned. A table is provided showing historical changes of strength (to include long-range bombers) for the midyears of 1962 to 1975.[41] (No indication is given, however, of what inventory the bomber strengths at each midyear fall into.) And the bomber forces of NATO (excluding the USA) and the Warsaw Pact (excluding the USSR) are also depicted.[42] Although The Military Balance

opens with a textual discussion of strategic weapons, no attempt is made to discuss bomber effectiveness other than (1) noting that the U.S. had completed procurement of the short-range attack missile (SRAM) and was to make the procurement decision on the B-1,[43] and (2) commenting that

> Deployment began during the year of the supersonic Backfire, a swing-wing aircraft of medium range (but one version is capable of in-flight refuelling). A new air-to-surface missile with a range of 800 km is reportedly under development for Backfire.[44]

Some general observations concerning these three documents and their approaches to portraying the bomber force contribution are now in order. First, although all three utilize Level 1 (inventory count) indices, there is a general (although not complete) tendency to list figures without providing the appropriate inventory categories, a problem discussed in the second section of this paper. Strictly speaking, the only bomber forces that actually enter into measuring military effectiveness at the point that a nuclear war begins are bombers launched in a surprise attack or on alert (either day-to-day or generated), since they are the only bomber forces that are likely to survive the initial exchange.[45] Alert figures are normally classified, and it thus is difficult to give even a general impression of what uninterpreted bomber inventories contribute to force effectiveness. That being the case, it would be prudent for the appropriate caveats to be included with listings of inventory-count indices.

Second, although one study (that of the IISS) gave Level-II performance indices for bombers, the meanings of these indices

were inadequately explained. This was especially evident in listing the Backfire as a medium-range bomber based on an unrefueled maximum range figure, and then discussing the refueling capabilities of the Backfire. The question here is obvious: does it matter how it gets from point A to B if it can be established that it can do so? Since the issue of which kind of bomber the Backfire is has significant SALT implications which would affect the military balance, an adequate explanation of the meanings of indices would seem to be appropriate.

Third, two of the documents (the FY 77 Posture Statement and the Library of Congress study) attempt to use Level-IV (gaming) results, although both do so in an indirect way. The Posture Statement makes claims which rely in part on the outcome of various war games conducted within DOD. Although these games are normally classified, they will for the most part be made available to the audience that the Posture Statement is immediately directed to -- the Congress of the United States. As for the Library of Congress study, its attempt to portray and interpret the interaction of numerous Level-II indices with one another makes much of its text methodologically related (as perhaps a second or third cousin) to gaming activities.

With respect to both documents, credibility is a crucial issue, since they play roles in a public debate concerning the spending of billions of dollars -- a debate likely to strike sensitive nerves in the public consciousness. Where credibility is a key concern, elaborate discussion of the force balance

indices used would appear to be a most appropriate way to help establish that credibility, by explaining in minute detail the rationale for selecting the indices that are in fact used. The goal to aim at in such explanations should be an appropriate balance and portrayal of simple yet accurate indices with detailed rationale and qualification. The simple portrayals allow those who have neither the time nor inclination for interpreting detailed rationale to nevertheless use force balance documents, gaining at least a proper tone of what the balance involves. Moreover, although cybernetic decision theory may be correct concerning the need for decision-makers to conceptualize issues in terms of simple categories, this fails to address the fact that most busy decision-makers are supported by extensive staffs. Staff expertise may well be capable of dealing with the more complex analyses, and the staff decision as to which set of simple categories (or indices) should be advocated to their superiors thus has an important role to play in forming the perceptions of decision-makers.

A fourth observation concerns the need to portray bomber forces not simply as balancing other bomber forces but as playing a significant role in the overall strategic balance. The FY 77 Posture Statement did this, albeit in a limited fashion. A more detailed assessment might proceed by reviewing what would be lost by deleting bomber forces from an overall strategic offensive force capability. The following remarks

outline how such an assessment might proceed given the assumptions that when bombers are eliminated, other components of the offensive forces are retained.

For the United States, eliminating bomber forces would drastically decrease the total deliverable megatonnage available. Today, U.S. bombers account for less than one-fourth of U.S. strategic delivery systems, yet the fully generated bomber force would carry over half of total strategic megatonnage. Thus, in terms of megatons per delivery system, bombers provide an important means of balancing asymmetries in missile forces.

Also for the United States, bombers are not a "first strike" system. By their nature, bombers contribute to strategic stability, since their long time-of-flight (compared with SLBMs or ICBMs) essentially eliminates them from taking the role of a surprise attack force. Similarly, this allows bombers to be launched on warning (genuine or otherwise) without final commitment to a target. Deliberate selection of bomber alert postures can also play an important role in signalling resolve and purpose in a crisis. Bombers are sovereign-based forces. Thus, an attack upon them would require an enemy to detonate nuclear weapons on or over the United States -- a decision which could not be taken lightly. This also contributes to strategic stability.

With the radars and electro-visual systems now installed and with on-board crews to use them, bombers can be employed for

reconnaissance and damage assessment missions, should nuclear war occur. They would thus be capable of "battlefield" assessment of target damage by weapons arriving earlier and the subsequent attack of any targets found to not have been destroyed. Moreover, unlike missiles, bombers are not self-expending. After striking their targets, bombers could be recovered at a large number of widely dispersed bases to form an important part of a residual force which can be used to restore deterrence or perform follow-on strikes.

Bombers provide essential insurance against presently unanticipated, yet possible, failure in other strategic systems. They are the only strategic delivery system under direct human control from point of launch to the target. This is an invaluable hedge against unforeseen problems, given the ingenuity of the human mind to cope with the unexpected.

Finally, bombers enhance protection of other elements of the strategic offensive forces. It is virtually impossible for the Soviets to launch a successful, coordinated attack upon both bomber and ICBM forces. If the Soviets attacked both force components with ICBMs, time-of-flight would provide warning of the incoming attack. Even if the U.S. decision-makers were cautious in interpreting the warning, they know full well they can launch the alert bomber force and later recall it, should the warning turn out to be mistaken. The Soviets might devise tactics to decrease warning time by launching an SLBM attack

from submarines close to U.S. shores. Even if such an attack could be coordinated, however, to destroy a significant portion of the alert bomber force, it could not destroy the silo-based ICBM force, since SLBMs lack the accuracy to attack such hardened targets. Thus, even if the Soviets perfected ASW techniques which could threaten the U.S. sea-launched ballistic missile force, the mutually protecting bomber/ICBM force could not be destroyed without warning.

Turning to the Soviet bomber force, one finds that the same analysis cannot be applied directly due to doctrinal and force structure considerations which give different roles to the Soviet strategic bomber force. The operative word here is 'strategic,' since prudent Soviets planners must posture their strategic forces for at least two separate wars. On the one hand, Soviet planners must prepare for a strategic contingency with NATO, involving (from their point of view) conflict with several nuclear-capable allies.[46] On the other hand, prudent Soviet planners must account for the nuclear forces of the People's Republic of China. Viewed from this perspective (as opposed to a perspective focusing solely on bomber ranges), the Soviet <u>strategic</u> bomber force which includes medium and even short range bombers turns out to be a considerable force whose elimination would significantly affect Soviet strategic nuclear capabilities.

As a final observation on portraying bomber forces, cruise missiles must be mentioned. Cruise missiles cannot be viewed

as a viable alternative to the manned bomber in light of current defensive capabilities. Cruise missiles are nothing but preprogrammed, low, relatively slow, unmanned delivery systems, albeit ones with a small radar cross section. The last factor alone cannot ensure cruise missile survival in the face of concentrated defenses. Cruise missiles do not have the flexibility that a manned penetrating bomber has to detect, degrade, or destroy enemy defenses, and cannot be considered as replacements for bombers.

This is not to say that cruise missiles have no value, however. They can enhance the effectiveness of a bomber force, because many targets in a nuclear war could be expected to be poorly defended or entirely without defenses. Thus, cruise missiles can allow more target coverage for a penetrating bomber force. This suggests that cruise missiles should be considered in the strategic balance, not as a replacement for manned bombers but as an enhancing factor, somewhat like the short range attack missile is.

These comments have briefly reviewed some considerations on portraying bomber forces in a strategic balance. A similar analysis of portraying counterforce capabilities will now be performed.

Counterforce Capabilities

Several categories of targets were discussed earlier in this paper: area targets, like a large military base or an urban area; soft point targets, like an exposed flight tower or a skyscraper housing financial records; and hard point targets, like an underground missile silo or command and control center, constructed so as to resist nuclear effects. "Hardening" is a term which normally refers to the efforts taken to resist the various blast and pressure effects of the nuclear burst.[47]

Strictly speaking, counterforce is not a term denoting unambiguously a target type, since military targets can be of any of the three types listed (as the examples selected demonstrate). However, since many of the highest value military targets relevant to the strategic nuclear balance have been hardened, and since the ability to destroy a hard target automatically connotes some level of ability (though not necessarily an optimized one) against soft targets, the search for counterforce effectiveness has been gauged primarily by one's "hard target kill capability." Attention thus turns to measures of merit for hard target kill capability.

These measures of merit have directly entered the issue of maintaining a strategic nuclear balance. In March, 1974, Secretary of Defense Schlesinger articulated in that year's Posture Statement what would become the basic rationale behind U.S. counterforce measures:

For a period of time prior to 1960 the United States had a virtual nuclear monopoly. By 1960 it was perceived that our monopoly advantage would ebb; and, in fact, it not only began to ebb, but by 1966-67 the Soviet Union had a very substantial intercontinental counter deterrent. During the early 1960's it was stated quite clearly by President Kennedy -- and also by a large majority of Americans in both parties -- that the United States needed alternatives other than suicide or surrender, that it needed options which did not imply immediate escalation to nuclear war... A development of more recent years is the accelerated improvement in Soviet missile technology. The Soviet Union now has the capability in its missile forces to undertake selective attacks against targets other than cities. This poses for us an obligation if we are to ensure the credibility of our strategic deterrent to be certain that we have a comparable capability in our strategic systems and in our targeting doctrine, and to be certain that the USSR has no misunderstanding on this point.[48]

This paper will not address the controversy that ensued in the subsequent counterforce debate.[49] Instead, it will start from the premise that stated American policy is to retain a rough equivalence of strategic forces with the Soviet Union, to include an option to strike accurately at military targets, including some hardened sites.[50] The question then becomes twofold:

- What indices accurately measure counterforce capabilities?
- How can a balance of counterforce capabilities be best portrayed?

If all military targets were area or soft point targets, relatively simple indices would suffice. For area targets, EMT,

delivery system/weapon reliability, and penetration probabilities would give a fairly good gauge of force effectiveness, when put together in a war game. Proper communications of the results would thus create the atmosphere within which counterforce balances could be established and/or maintained. Similarly, for soft point targets much the same thing could be accomplished, with even less emphasis on EMT. For hard point targets, however, the difficulty becomes establishing weapons effectiveness measured in terms of probabilities of kill against the hardened targets.

As was discussed earlier in the paper, one measure which attempts to do this task is "lethality" (or "countermilitary potential"). Some publications have in fact undertaken to portray comparative lethality figures for the U.S. and the Soviet forces.[51] By themselves, such figures mean nothing. Weapons accuracy and yield must be dynamically interwoven with the target systems that the various forces are directed against before they become meaningful. At least one published presentation has attempted to do this.[52] Its methodology is worth examining.

Kosta Tsipis uses two measures of merit to compute force balance. One measure is that already discussed: namely, to compute lethality for U.S. and Soviet ballistic missile systems, to multiply various lethalities by number of systems deployed, to sum the results, and to display it in tabular and graphic form.[53] This process suffers from at least two major shortcomings.

First, there is the problem of "data lag" which affects all attempts to compute quantitative force comparisons, but which impacts most severely on those comparisons done outside the official defense community and intended for publication. Five months before Tsipis's analysis was published the FY 76 Posture Statement had revealed that "the Soviets have already begun what will be a very substantial, indeed unprecedented, deployment of large new ICBMs in the first quarter of this year."[54] This deployment rendered invalid the "balance" portrayed by Tsipis's figures.

Even if perfectly accurate inventory and performance information had been available, however, tables portraying "Total Lethality of Missile Force (K x N)" still tells one nothing about force effectiveness. To measure force effectiveness, data bases must be introduced for the target systems, and the vulnerabilities of the various hardened targets must be computed.[55] Assuming that perfect information was available, two approaches could be taken to compare counterforce capability.

The first approach might proceed roughly as follows:

(1) select the least vulnerable hardened target in the enemy's target base;

(2) compute P_k for each weapon in your inventory against this selected target;

(3) sum the P_k's.

This procedure would yield a rough feel for your weapons effectiveness against the hardest enemy target (and, hence, against other targets in the data base). It does not directly

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translate into the total number of hard targets that can be "killed";[56] however, it does indicate one level of force capability. If similar analyses can be performed for the enemy, comparative figures taking account of the different target bases will have been established.

A second, and more informative, approach would be to devise elaborate gaming models. Such models are dependent upon their assumptions, however: e.g., which weapons will be directed against which targets and which defenses will be deployed to meet them? The conclusions would thus be tied to specific scenarios, and as the scenarios change, so will the conclusions.

These are some of the considerations one should be aware of in attempting to devise indices for measuring counterforce capabilities. As was the case with the other aspects of the strategic balance, how the counterforce issue is discussed will be an important determinant in affecting perceptions, perhaps as important as the indices themselves.

Conclusions

This paper has examined some of the dimensions of a strategic nuclear balance. Perhaps the central conclusion to be drawn from the exercise is that regardless of the measuring indices chosen, the skill with which these indices are articulated in sources which have achieved a high degree of credibility will continue to influence and shape public perceptions of the balance. Public perceptions are not enough, however. There is that crucial factor of confidence which military commanders and their leaders must have that if

deterrence fails, the forces will function as anticipated to fulfill their strategic objectives. Herein lies the crux of the issue.

It is as true for the strategic as it is for the conventional balance that the aspect of military professionalism which Samuel P. Huntington termed "expertise in the management of violence" forms an environment for the day-to-day functions of military forces which represents the "reality" that military postures are tied to. Unlike scenarios devised in peacetime to model conventional war, however, scenarios for nuclear conflict are without historic precedent in a fundamental way. Hence whatever strategic indices are devised as a result of gaming activities, those indices must contain wide hedges against the heightened uncertainties involved in nuclear war.

Finally, the images one carries in one's mind tend to structure perceptions, since many perceptions have as high a pictorial as a conceptual content. What is the appropriate image for a strategic nuclear balance? Perhaps there is no singularly proper image, but one particularly powerful one is of two groups of individuals pulling and straining on narrow ledges divided by an abyss, in a monumental tug-of-war. Some grow old in the process. Others are added to the grim game. There are frequent maneuvers for advantage, but both sides paradoxically share a common interest in not having the rope violently snap. Add to this a dense yet uneven fog enveloping the arena, such that measuring one's own forces is possible but measuring those of the opponent is difficult, and one begins to grasp a pictorial representation of the problems involved in measuring the strategic balance.

deterrence fails, the forces will function as anticipated to fulfill their strategic objectives. Herein lies the crux of the issue.

It is as true for the strategic as it is for the conventional balance that the aspect of military professionalism which Samuel P. Huntington termed "expertise in the management of violence" forms an environment for the day-to-day functions of military forces which represents the "reality" that military postures are tied to. Unlike scenarios devised in peacetime to model conventional war, however, scenarios for nuclear conflict are without historic precedent in a fundamental way. Hence whatever strategic indices are devised as a result of gaming activities, those indices must contain wide hedges against the heightened uncertainties involved in nuclear war.

Finally, the images one carries in one's mind tend to structure perceptions, since many perceptions have as high a pictorial as a conceptual content. What is the appropriate image for a strategic nuclear balance? Perhaps there is no singularly proper image, but one particularly powerful one is of two groups of individuals pulling and straining on narrow ledges divided by an abyss, in a monumental tug-of-war. Some grow old in the process. Others are added to the grim game. There are frequent maneuvers for advantage, but both sides paradoxically share a common interest in not having the rope violently snap. Add to this a dense yet uneven fog enveloping the arena, such that measuring one's own forces is possible but measuring those of the opponent is difficult, and one begins to grasp a pictorial representation of the problems involved in measuring the strategic balance.

FOOTNOTES

[1]Carl von Clausewitz, On War, trans. by J.J. Graham, ed. by Anatol Rapoport (Baltimore: Penguin Books, 1968), p. 277.

[2]Ibid., p. 276.

[3]Sun Tzu, The Art of War, trans. by Samuel B. Griffith (New York: Oxford University Press, 1963), p. 66. Sun Tzu's claim for deception is a direct forerunner of Liddell Hart's own notion of the 'indirect approach'.

[4]B.H. Liddell Hart, Strategy, 2nd Revised Edition (New York: Frederick A. Praeger, Publisher, 1967), p. 337. Author's emphasis removed.

[5]The kind of debate I have in mind here is that discussed by Peter Winch in The Idea of a Social Science and its Relation to Philosophy (London: Routledge & Kegan Paul, 1958).

[6]Sec J. David Singer, "The Levels-of-Analysis Problem in International Relations," in James N. Rosenau (ed.), International Politics and Foreign Policy (New York: The Free Press, 1969), pp. 20-29.

[7]A cruise missile can be launched from aircraft, ships, or land platforms. It has been discussed in SALT II alternately as a weapon (like a MIRVed warhead) and as a delivery system.

[8]For a discussion of how this relates to SALT methodology, see David Aaron, "A New Concept," Foreign Policy, 17 (Winter 1974-75), pp. 157-165.

[9]This is also a problem for assessing the capabilities of ballistic missiles with multiple warheads.

[10]They would never totally determine force effectiveness, as chance remains the handmaiden of strategy.

[11]CEP is a measure established by empirical data; it gives the radius for a circle within which 50% of launched weapons characterized by the specified CEP can be expected to fall.

[12]It is instructive here to recall von Clauswitz's admonition that "There is no human affair which stands so constantly and so generally in close connexion with chance as War." This is especially true with respect to nuclear war, which has no appropriate precedent.

[13]Ballistic missile range, for instance, affects submarine survival by increasing the operating area within which submarines are on-station and thus complicating the enemy's anti-submarine warfare (ASW) activities.

[14]Well documented Soviet civil defense and industrial/urban hardening and dispersal activities are of particular concern in assessing the military balance. A comprehensive debate concerning how the United States should react to those efforts is presented in Arthur A. Broyles, Eugene P. Wigner, and Sidney D. Drell, "Civil Defense in a Limited War -- A Debate," Physics Today (April, 1976).

[15]A discussion of the mathematics of nuclear effects can be found in Kosta Tsipis, "Physics and Calculus of Countercity and Counterforce Nuclear Attacks," Science, 187:4175 (7 February 1975), pp. 393-397.

[16]Uri Ra'anan, The Changing American-Soviet Strategic Balance: Some Political Implications, Memorandum prepared at the Request of the Subcommittee on National Security and International Operations of the Committee on Government Operations, United States Senate, 92d Congress (Washington, D.C.: U.S. Government Printing Office, 1972), p. 4.

[17]John M. Collins and John Steven Chwat, United States/Soviet Military Balance: A Frame of Reference for Congress, A Study by the Library of Congress Congressional Research Service prepared for the Senate Committee on Armed Services (Washington, D.C.: U.S. Government Printing Office, 1976).

[18]Charles Wolf, Jr., Perceptions of the Military Balance: Models and Anecdotes. RAND Paper 5402 (Santa Monica, California: The RAND Corporation, March 1975), pp. 10-11.

[19]Ibid., p. 11.

[20]An analogy here can be drawn to what the late Andre' Beaufre called "the critical influence of modern mass communications and its almost decisive impact in the areas of national and international public opinion." Strategy for Tomorrow (New York: Crane, Russak & Company, Inc., 1974), p. 3. A nuclear strategist must necessarily consider the extent to which modern mass communications allow perceptions of strategic strength to be manipulated.

[21]John Steinbruner, "Beyond Rational Deterrence: The Struggle for New Conceptions," World Politics, XXVII: 2 (January 1976).

[22] Report of Secretary of Defense Donald H. Rumsfeld to the Congress on the FY 1977 Budget and Its Implications for the FY 1978 Authorization Request and the FY 1977-1981 Defense Programs (Washington, D.C.: January 27, 1976). Hereafter, this will be referred to as the FY 77 Posture Statement.

[23] United States/Soviet Military Balance, op. cit..

[24] The Military Balance, 1975-1976, (London: The International Institute for Strategic Studies, 1975).

[25] Several aspects of this year's debate deserve special mention, insofar as they are quite relevant to the issue of portraying bomber forces. The production decision on the B-1 will result in a program to develop and procure 244 B-1s over a 16 year span at an estimated cost of $16.6 billion in constant FY 77 dollars ($21.4 billion when inflation estimates are included). The Air Force had programmed the B-1 as the most cost-effective means of modernizing the U.S. strategic bomber force, based in part upon Air Force/Office of the Secretary of Defense assessment of extensive war games designed to test bomber force effectiveness for various types of bomber forces. Shortly before the Secretary of Defense's Posture Statement was released, a Brookings Institution Study in Defense Policy entitled Modernizing the Strategic Bomber Force and authored by Alton H. Quanbeck and Archie L. Wood was published. This study challenged the DOD request for the B-1, claiming that other means of modernizing the bomber force were available at lower cost (a claim which subsequent debate revealed to be a modernization option limiting the U.S. to a minimum deterrence posture in the face of intensified Soviet defensive efforts). In the United States, the debate crystallized around the leadership of Senator Proxmire (who would suspend funding for the B-1) and Senator Goldwater, speaking in defense of the B-1. In a syndicated column published on May 18, 1976, the respected American journalist James J. Kilpatrick wrote: "It doesn't happen often, but now and then the United States Senate provides a forum for debate in the grand manner. We have been hearing such a debate off and on for the past three weeks. The question is: Resolved, that further funding of the B-1 bomber should be suspended." Most importantly, James Kilpatrick goes on to observe: "It is a pity that the two senators are debating in a virtual vacuum. This is the kind of story that television cannot possibly cover. Even the largest newspapers can barely nibble at the edges. Mr. Proxmire and Mr. Goldwater are speaking to a handful of colleagues, and they are making their cases in the Congressional Record. The matter is much too important to be left at that."

[26] Figure 2 is taken from p. 44 of the FY 77 Posture Statement, where it appears as Table IIA-1.

[27] This point is expanded in the text of the FY 77 Posture Statement on p. 45: "The lead-times associated with the development of strategic nuclear forces require prudence in planning ahead. It takes up to 18 months to prepare a missile silo, around two and a half years to build a B-1, and about four years to construct a Trident submarine."

[28] Ibid., p. 51.

[29] Ibid., p. 67.

[30] United States/Soviet Military Balance, op. cit., p. III.

[31] Ibid., p VII.

[32] Ibid.

[33] Figure 3 is taken from p. 4 of the United States/Soviet Military Balance.

[34] Figure 4 is taken from p. 22 of the United States/Soviet Military Balance.

[35] Ibid., p. 3.

[36] Ibid., p. 4. The context of this statement suggests that 'lags' is to be interpreted in terms of pace of procurement and deployment programs.

[37] Ibid., p. 31. It should be noted here that while B-1s are seen as eventually replacing B-52s as B-52s are phased out of the bomber force by natural attrition or aging considerations, when the B-1 is first deployed, it will be in a mixed force of B-1s, B-52s, and FB-111s.

[38] The Military Balance, 1975-1976, op. cit.. Bomber figures are found on p. 72.

[39] Ibid., p. 73 (footnore w).

[40] Ibid., p. 73 (footnote t).

[41] Ibid., p. 73.

[42] Ibid., p. 75.

[43] Ibid., p. 3.

[44] Ibid., p. 4.

[45] This may not be true for certain counterforce scenarios in which only a limited nuclear attack takes place.

[46] This further points out the need for a military balance to reflect indices which account for total allied contribution, even at the strategic nuclear level.

[47] For a discussion of these effects, consult Samuel Glasstone (ed.), The Effects of Nuclear Weapons (Washington, D.C.: United States Atomic Energy Commission, 1962).

[48] Report of the Secretary of Defense James R. Schlesinger to the Congress on the FY 1975 Defense Budget and FY 1975-1979 Defense Program (Washington, D.C.: U.S. Government Printing Office, 4 March 1974), pp. 3-4. Underlining added.

[49] For a discussion of the issue which summarizes many facets of the debate, see Lynn Etheridge Davis, Limited Nuclear Options: Deterrence and the New American Doctrine, Adelphi Paper No. 121 (London: The International Institute for Strategic Studies, 1976).

[50] FY 77 Posture Statement, op. cit., p. 13. It should be noted that the policy has consistently also contained the qualification that U.S. programs do not permit nor aim to acquire a disarming first-strike capability against the USSR.

[51] Tsipis, "Physics," op. cit., p. 394.

[52] Kosta Tsipis, "The Accuracy of Strategic Missiles," Scientific American, 233:1 (July 1975), pp. 21-23.

[53] Ibid. See the tables and graphs on pp. 21 and 23.

[54] Report of Secretary of Defense James R. Schlesinger to the Congress on the FY 1976 and Transition Budgets, FY 1977 Authorization Request and FY 1976-1980 Defense Programs (Washington, D.C.: U.S. Government Printing Office, 5 February 1975), p. I-14.

[55] Tsipis attempts to accomplish this in "Physics," op. cit., pp. 396-397; however, his analysis suffers from at least two shortcomings. First, he treats probability of kill as if it were a direct function of hardness (psi) per se, without taking into account other target characteristics which influence vulnerability to nuclear effects. And second, he treats only part of the hardened targets bases, yet portrays his conclusions as if they represented a balance of total counterforce capability. For a more detailed treatment of Tsipis's methodology and conclusions, see Thomas A. Brown, "Missile Accuracy and Strategic Lethality," Survival XVIII:2 (March/April 1976).

[56]"Killing" a hard target is a relative concept, since it depends upon one's strategy. It may be the case, for instance, that merely doing light or moderate damage to the target (e.g., doing damage to a hardened command and control site which only renders it unusuable for several hours) is sufficient to achieve one's aims.

REVIEW OF STATIC MEASURES

OF THE STRATEGIC BALANCE

INDICATOR: NUMBER OF ICBM LAUNCHERS

DESCRIPTION OF INDICATOR

This indicator quantifies the number of ICBM launchers in the operational force. It counts as a launcher any deployed silo, soft-pad, or mobile launcher which has been identified as a type associated with the firing of a ballistic missile of intercontinental range.

SIGNIFICANCE OF INDICATOR

The number of ICBM launchers is one quantitative measure of the capability of the strategic forces. At present and during the near future (until accuracy and command and control of SLBMs improves), this indicator is a basic input to force exchange calculations which emphasize counterforce capabilities. It is one of the determinants in the hard target kill potential of a strategic force (as well as its value as a sink for the enemy's destructive potential). The salient feature of the indicator is its simplicity and ease of comprehension for an audience with little background in strategic force comparisons.

LIMITATIONS OF INDICATOR

The indicator does not provide a measure of the qualitative differences between ICBM launchers and between ICBMs. For example, the accuracy, number of RVs, reliability, and yield of various ICBMs is not differentiated by the indicator. An SS-18 launcher and MMII launcher are both counted as one unit. Another example of the lack of content in the indicator is its failure to distinguish between the hardness of different launchers which determines their resistance to attack. Consequently the indicator can be misleading when used alone as an indicator of the relative U.S./Soviet strategic balance.

It is, however, an important and useful indicator when used in conjunction with other indicators of force effectiveness.

ESTIMATE OF THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

It is estimated that the uncertainty in the value projected for the number of Soviet ICBM launchers is ± ________ launchers for fixed launcher deployments. For mobile ICBMs the uncertainty is ________________________.

261

INDICATOR: NUMBER OF SLBM LAUNCHERS

DESCRIPTION OF INDICATOR

This indicator quantifies the number of certain SLBM launchers in the operational force. It does not generally include all launchers for ballistic missiles deployed on submarines. It does, however, include those which both sides have tacitly agreed are "strategic" during the SALT negotiations.

SIGNIFICANCE OF INDICATOR

The number of SLBM launchers is another quantitative measure of the capability of the strategic forces. Since on station SSBNs are at present (and at least for the foreseeable future) completely survivable, this indicator is associated with the major contribution to the residual retaliatory capability after a first strike by the other side. As such, it is a partial measure of the deterrence provided by a residual force with the capability to attack urban/industrial targets. The strongest feature of the indicator is its simplicity.

LIMITATIONS OF INDICATOR

The indicator does not provide a measure of the qualitative differences between SSBNs nor between SLBMs. The potential vulnerability of SSBNs (hence SLBMs) will depend upon characteristics of the submarine. The characteristics of the SLBM determines its effectiveness in both a U/I and a counterforce role. It is, however, an important and useful indicator when used in conjunction with other indicators of force effectiveness.

262

ESTIMATE OF THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

Since the number of SLBM launchers is determined by the number of SSBNs which are easily accounted for, the uncertainty in the value of the indicator is small.

263

INDICATOR: NUMBER OF STRATEGIC BOMBERS

DESCRIPTION OF INDICATOR

This indicator quantifies the number of bombers in the operational force which are deployed for intercontinental attack with nuclear weapons. It does not include those bombers which are marginally capable of such a role if refueled in the air or deployed from forward bases. Judgments on whether or not a bomber has an intercontinental strategic role are based upon the bombers capability, its deployment, the training of its crew, and somewhat on how a side declares it will be used in conflict.

SIGNIFICANCE OF INDICATOR

The number of strategic bombers is another quantitative measure of the capability of the strategic forces. It is more clearly an indicator of retaliatory capability (as opposed to first strike capability) than are the numbers of ICBMs and SLBMs because of the relatively longer flight times to target associated with bombers. It is a visible and simple indicator of force comparison.

LIMITATIONS OF INDICATOR

The indicator does not provide a measure of the difference in effectiveness among different bomber types. For example, an FB-111 with gravity bombs and a B-1 with a full load of SRAMs both count as one unit. The indicator, used alone, does not provide information about the defenses which oppose penetration of the bomber (which may be of different relative capability than those defenses which oppose ballistic missiles). It is, however, a fundamental and useful indicator when used in conjunction with other indicators of force effectiveness.

264

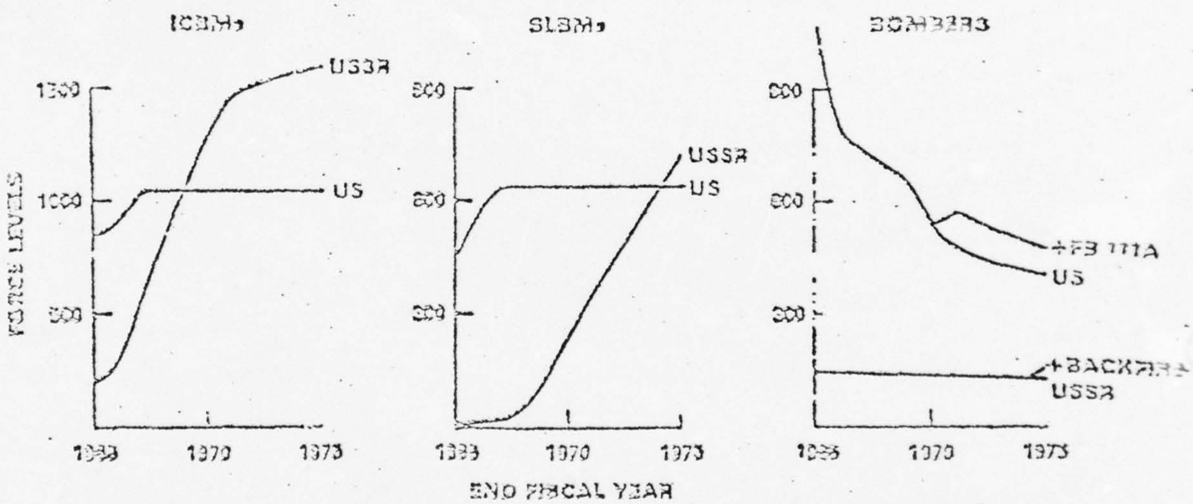
ESTIMATE OF THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

Strategic bombers, because of their size and their assignment to identifiable units are easily accounted for with very little uncertainty.

265

SAMPLE USE OF INDICATOR

CHANGES IN U.S./U.S.S.R. STRATEGIC FORCE LEVELS



Source Document: FY77 U.S. Defense Budget Perspectives, Donald Rumsfeld, SecDef, 26 February 1976

DISCUSSION

The trend depictions above were used to highlight the following facts:

<u>Changes in Strategic Nuclear Forces - U.S./U.S.S.R.</u>

The Soviets have increased from about 225 ICBMs in 1965 to some 1,600 today, having overtaken the U.S. in the late 1960s.

The Soviet submarine-launched ballistic missiles have grown from 29 to more than 700, while the U.S. has been level at 656.

266

In the bomber force, the U.S. maintains a lead.

These comparisons do not address qualitative differences in the two forces.

COMMENT ON THE USE OF THE INDICATORS

The use of the three individual indicators results in a simple display from which conclusions are easily drawn. They depict a situation in which the Soviet Union has either deployed more of a particular delivery system than the U.S. or the U.S. is unilaterally decreasing the magnitude of the deployment of a system. The plots convey a sense of the U.S. being overtaken by the Soviets in deployment of strategic offensive arms. The listed facts point out the domains in which one side or the other "leads". Such a display is correct and useful but it can be misleading if not accompanied by a display of other indicators of the strategic balance. Display of these indicators would reveal the qualitative differences between U.S. and Soviet systems within a particular class and the relative effectiveness of a particular class of systems in realistic scenarios of engagement related to deterrence which may occur as a result of U.S./Soviet foreign policy differences. For instance, additional information would be required for an observer to judge whether or not he would prefer to possess Soviet or U.S. strategic forces during any period of time. In addition, the prospect of an overall 2,400 aggregate level limit in SALT would tend to influence judgments concerning the meaning of "leads" in the number of deployed vehicles in a particular class.

267

INDICATOR: NUMBER OF STRATEGIC NUCLEAR DELIVERY VEHICLES

DESCRIPTION OF INDICATOR

The indicator is a composite of the number of deployed ICBMs, SLBMs, and strategic bombers.

SIGNIFICANCE OF INDICATOR

This indicator portrays a gross measure of the strategic offensive capability of each side. It is a simple measure since it is the sum of other simple measures of strategic capability. If one side were severely disadvantaged in a comparison of this indicator, it would either be judged inferior in strategic strength or else in possession of sufficient qualitative advantages in the force elements to balance the overall quantitative disadvantage.

LIMITATIONS OF INDICATOR

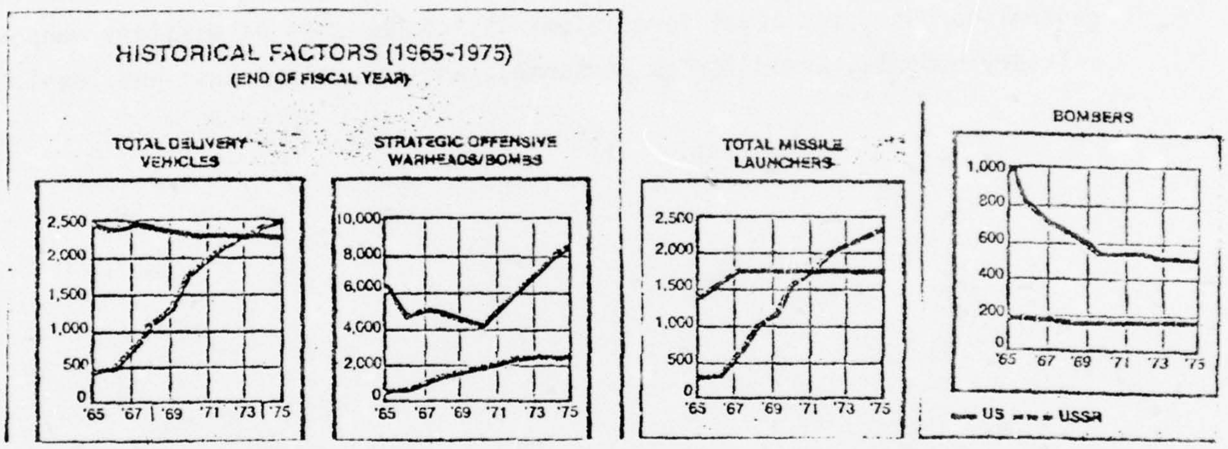
This indicator suffers from each shortcoming of its individual components. It is much too lacking in details which determine the effectiveness of individual elements of the strategic balance and the overall strategic balance itself. It is, however, useful and fundamental in measuring perceptions of the strategic balance as viewed by general audiences.

ESTIMATE OF THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The uncertainty associated with the composite indicator is a combination of uncertainties associated with its components. The composite uncertainty is small because the number of deployed ICBMs, SLBMs, and strategic bombers can be accurately determined.

268

SAMPLE USE OF INDICATOR



Source Document: Air Force Magazine, March 1976

DISCUSSION

The author used a display of the trend of the number of strategic nuclear delivery vehicles, along with other indicators to draw the following conclusion:

"The current Soviet leadership grew up with and fought for the realization of their power.... They may well wish to exploit it--both politically and militarily--to test the waters of Western Resolve. A major aspect of our future national strategy to control Soviet expansionism will be to confront them with clear and unmistakable risks, whatever the nature of the challenge, so that they conclude the game is not worth the candle.... The U.S. Congress, whose actions on this year's and next year's defense budgets will determine whether Western resolve will remain credible or not."

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COMMENTS ON THE USE OF THE INDICATOR

The rather sweeping conclusion would be difficult to support based upon a display of the trend of the number of strategic nuclear delivery vehicles or upon the trend of its composite parts. It does, however, provide a gross indication of the strategic balance which, in conjunction with the trend of other indicators of the U.S./Soviet military balance, supports the general conclusion. The author used a wide range of indicators to support the conclusion. Among these were relative production rates of certain strategic, general purpose, and naval force elements, comparisons of military manpower, military budgets, armed forces personnel, and technology base and level.

270

INDICATOR: NUMBER OF RVs/WARHEADS

DESCRIPTION OF INDICATOR

This indicator includes the number of nuclear warheads on operational strategic bombers as well as the number of reentry vehicles on deployed ICBMs and SLBMs. It is usually displayed as the sum of such weapons in the deployed inventory. It is generally not useful to display the number of warheads/RVs in a particular force element, e.g., in the SLBM force.

SIGNIFICANCE OF INDICATOR

The number of nuclear warheads is related to the number of targets which can be attacked. For targets which are easily destroyed, it is a handy tool for a gross estimate of the destructive potential of a force element (given that sufficient weapons exist to overcome the degradation due to weapon system reliability).

LIMITATIONS OF INDICATOR

The number of targets destroyed is not necessarily the same as the number attacked. Consequently, the indicator is not directly useful when the target structure has characteristics (e.g., hardness, mobility) which mitigate the attack effectiveness or when the attack scenario imposes limitations on the number of weapons which can be usefully employed (e.g., fratricide and mutual interaction effects) or when the attack scenario allows the attacked party to employ measures to diminish the severity of the attack (e.g., sheltering population).

271

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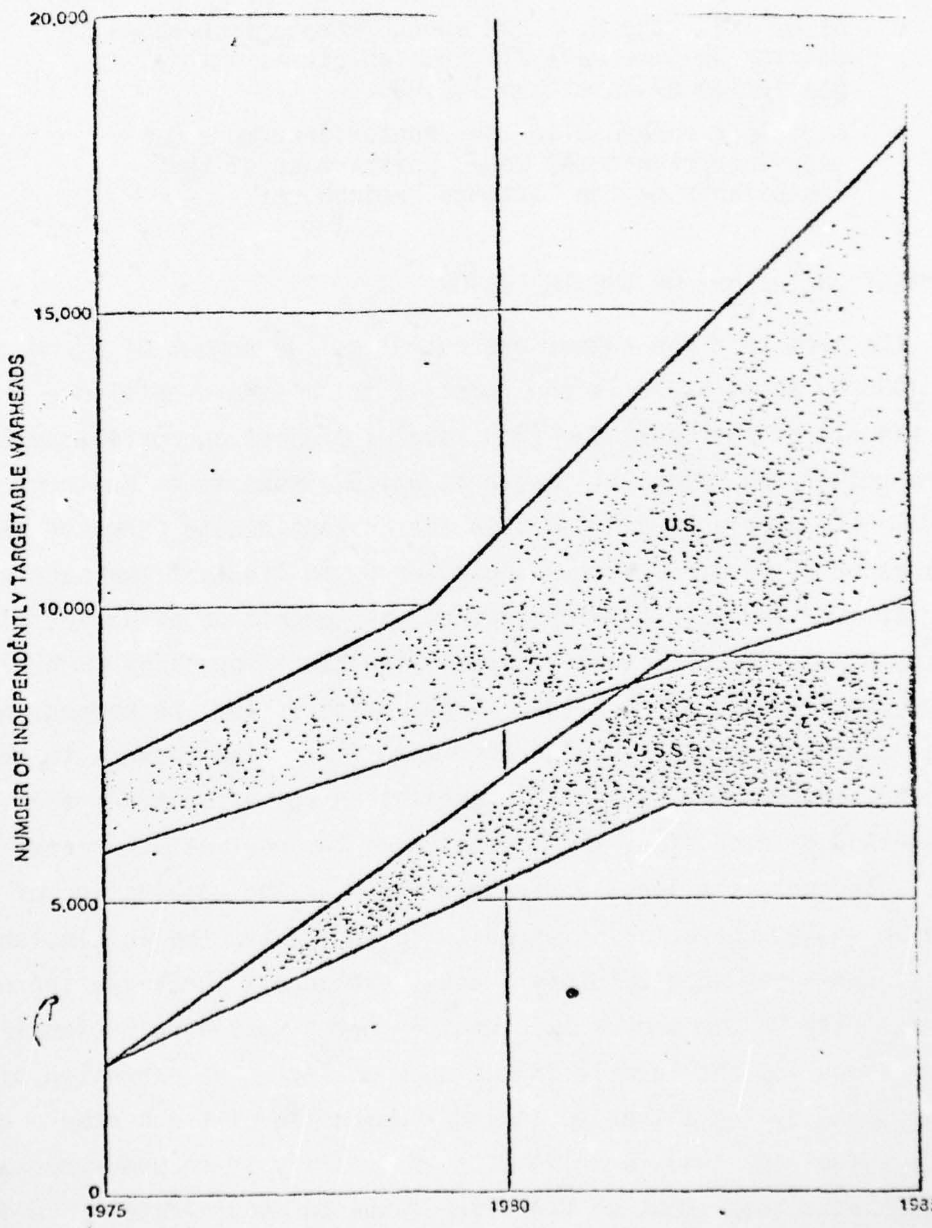
271

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The uncertainty in the number of RVs/warheads in the Soviet strategic force is mainly due to the uncertainty associated with the number of warheads per delivery vehicle since the number of vehicles can be determined quite accurately.

272

SAMPLE USE OF INDICATOR



Source Document: "The Proliferation of Nuclear Weapons", William Epstein, Scientific American, Vol. 232, No. 4, April 1975.

273

DISCUSSION

The author displays a "conservative" estimate of the number of strategic nuclear warheads each side could deploy under the terms of the Vladivostok accord. He concludes that:

- Each of the two superpowers can have 20,000 or more strategic nuclear warheads under the agreement.
- As of 1974, the U.S. had enough strategic weapons to destroy 36 times all 218 Russian cities with a population of more than 100,000.
- A nuclear exchange in the counterforce mode (of undefined magnitude) would poison most of the inhabitants of the northern hemisphere.

COMMENT ON THE USE OF THE INDICATOR

The fact that the author overestimates the number of planned U.S. warheads in 1985 by about 5,000 is the least of the misrepresentations incorporated in the use of the indicator (DoD sources project approximately 13,000 U.S. warheads). The "overkill" argument which ensues from the trend analysis completely overlooks or dismisses the current debate focussed on the character of future U.S. strategic forces in light of the pace of current Soviet ICBM and SLBM developments and the magnitude of Soviet air defenses which oppose the U.S. bomber force. Legitimate questions concerning the proper employment of strategic forces arise during the process of asking what course to pursue should deterrence fail. The answers to these questions depend, inter alia, upon likely escalation scenarios, the reserve force possessed by each side, the mechanics of the post attack recovery process, etc. In fact, the least understood issue is the combination of policy and weapon system characteristics which in fact deter the initiation and continuation of an escalatory nuclear exchange. The targeting of any one Soviet city 36 times over is certainly not a part of a rational thought process during the formulation of such policy. The extension of such assertions by the author to include "poisoning of the northern hemisphere" simply does not come to grips with the reality of recovery mechanisms and a realistic assessment of the risks taken to assure deterrence in a stable strategic environment.

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INDICATOR: EQUIVALENT MEGATONNAGE OF THE STRATEGIC FORCE

DESCRIPTION OF INDICATOR

The equivalent megatonnage (EMT) of a nuclear weapon is the yield of the weapon altered by scaling factors which provide a gross measure of its effectiveness against soft area targets. The scaling factors are:

$$EMT = \begin{cases} Y^{1/2}, & \text{for yields greater than one megaton} \\ Y^{2/3}, & \text{for yields less than one megaton} \end{cases}$$

where EMT and Y are in megatons of destructive power. The EMT of the strategic force is the sum of the EMT of each nuclear weapon in the deployed force.

SIGNIFICANCE OF INDICATOR

EMT is a crude indicator of the capacity of a particular weapon or of an aggregate force to damage soft area targets. If delivery accuracy is adequate to place the weapon within the boundary of the area target (it generally is) the important difference in comparing the effects of weapons of different yields is their lethal area which scales as the yield to the two-thirds power. For weapon yields in excess of one megaton, however, the lethal area would exceed the size of all but the largest area targets, hence the lower scaling factor (empirically arrived at) is commonly used for larger yield weapons. Although the EMT measure is approximate, its validity as a surrogate for the ability to damage soft area targets is generally accepted.

275

LIMITATIONS OF THE INDICATOR

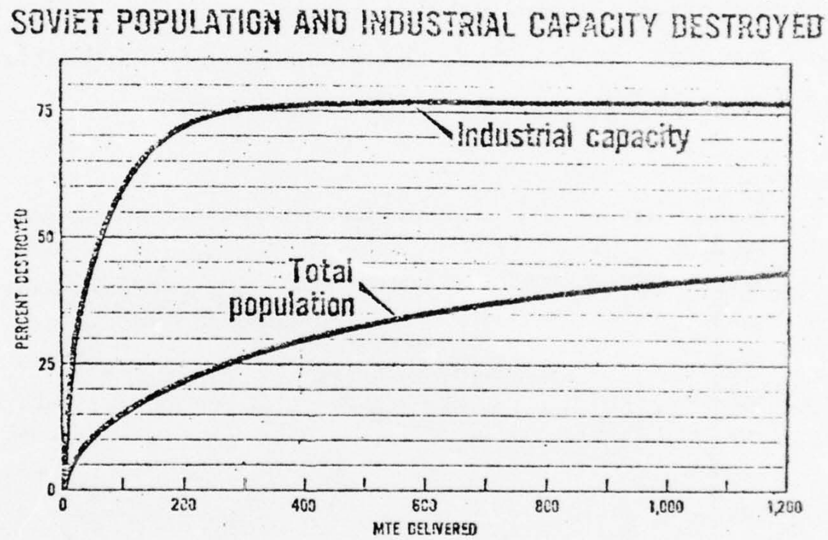
EMT is only an approximate indicator of the damage against soft area targets. The scaling law for low yield weapons, $Y^{2/3}$, is proportional to the lethal area of a weapon in an infinite plane over which the population is uniformly distrubuted. This law and the $Y^{1/2}$ law for high yield weapons are quite good for damage on U.S. cities which are spread out due to their suburban character. These laws are poor for Soviet cities which are highly urban. In addition, the indicator can be used by the unsophisticated to draw far reaching conclusions based on calculations using this gross and approximate static indicator. For example, the effect of shelters and evacuation of population can be overlooked when using EMT as a criterion for the sufficiency of a force posture.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The uncertainty in the EMT of a given warhead depends upon the uncertainty associated with the value of its yield. Since the yield of our own weapons is not predictable to better than $\pm$ 10 percent, Soviet yields are at least this uncertain. The uncertainty in the EMT of the total force depends upon the uncertainty of each element of the force.

276

SAMPLE USE OF INDICATOR



Source Document: Statement of Rep. Thomas J. Downey before the House Subcommittee on International Security and Scientific Affairs on the Vladivostok Accord: Implications to U.S. Security, Arms Control, and World Peace, 94th Congress, 1st Session, June 24, 25, and July 8, 1975.

DISCUSSION

The author asserts that the Soviets are deterred from a nuclear attack on the U.S. if the U.S. has sufficient inventory of nuclear weapons to destroy about one-third of the Soviet population and about two-thirds of Soviet industry. He goes on to state that the entire purpose of our nuclear forces is to give us absolute assurance that we can achieve destruction at the 400-EMT level. In addition, he believes that our objective should not be to push our ability toward the right side of the curve (region of diminishing return). He asserts that this would have literally no effect on the strategic balance.

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COMMENT ON THE USE OF THE INDICATOR

The author does not use the proper scaling factors for calculating EMT (uses $Y^{2/3}$ for all yields). Moreover, the author's conclusions are examples of how a gross index of only approximate applicability to reality can be misused. Although the author assigns factors to the U.S. force inventory to account for vulnerability and losses during penetration to assess the adequacy, he does not account for the effect of a possible civil defense posture. Even rudimentary shelters and simple evacuation plans can alter the results considerably. As seen from the figure below, substantial degradation in retaliatory capability can result from these measures.

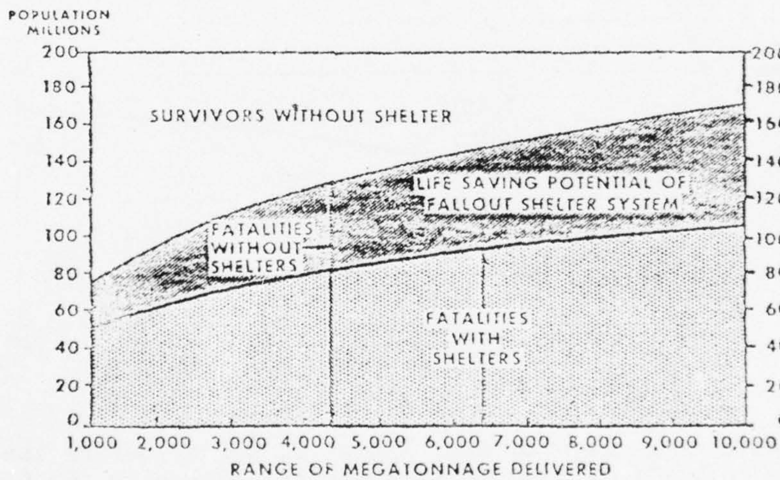

FIGURE 1.—Lifesaving potential of fallout shelter system in attacks against military-urban-industrial targets. In event of attacks against military targets alone, total fatalities would be reduced and lifesaving potential of shelters would be increased. (Source: Composite of Department of Defense damage-assessment studies.)

Source: Personal and Family Survival, Office of Civil Defense, SM3-11-A, November 1966.

In addition, the conclusions are drawn as if the recent dialogue on limited attacks had not occurred. They ignore the fact that U.S. forces should not be structured and employed so that the U.S. has only the option to retaliate against Soviet cities in the event deterrence fails. The fact that such a U.S. retaliatory capability has little credible deterrent value

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MEASURING THE STRATEGIC BALANCE. WORKING PAPERS FOR THE INTERNA--ETC(U)
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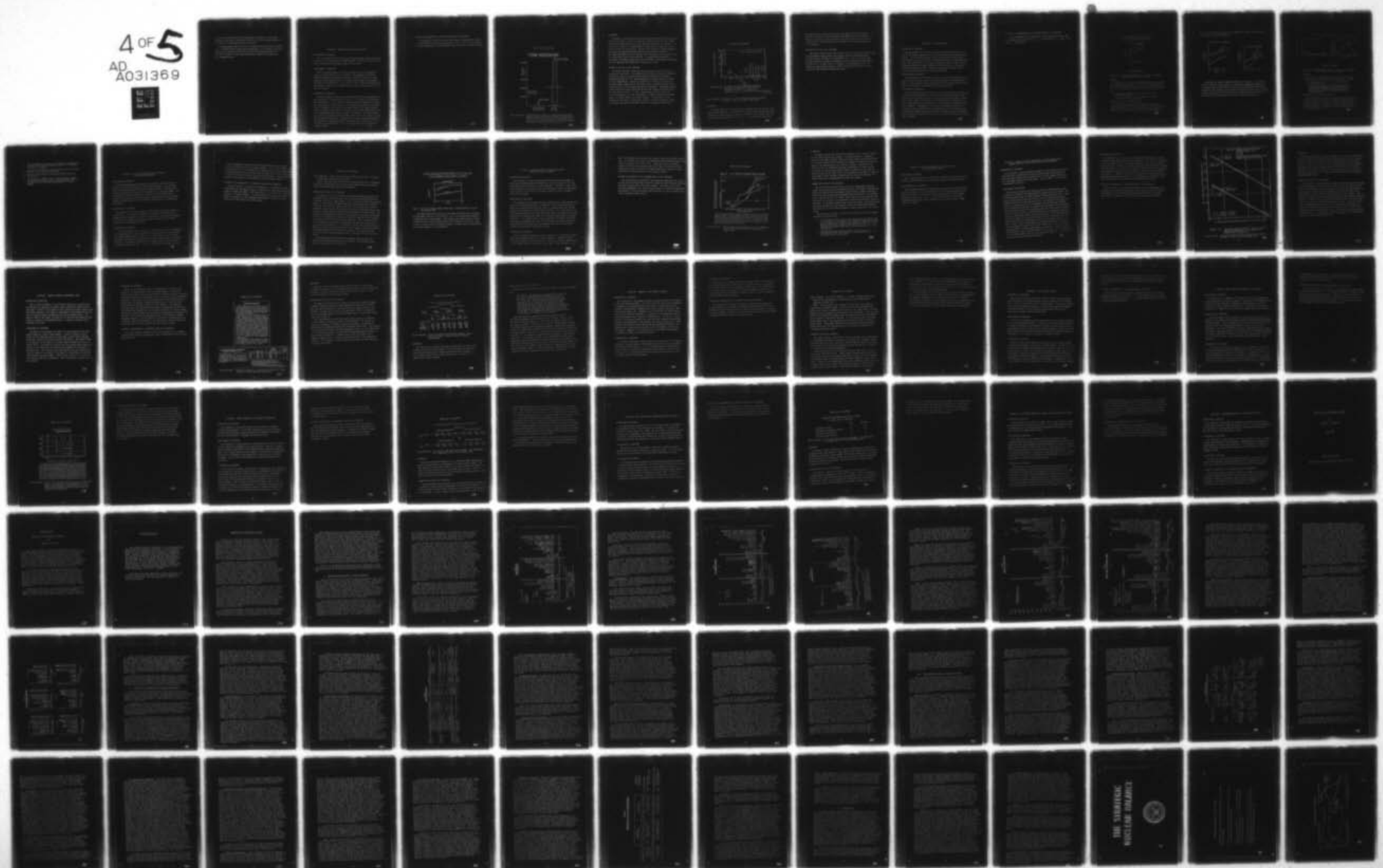

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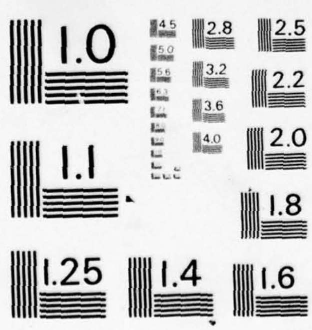

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

in the event the Soviets have the capability to attack U.S. forces and withhold a sufficient reserve force to hold U.S. cities hostage against U.S. retaliation, is completely missed by the author.

The approximate nature of EMT as an incomplete and gross static indicator of the strategic balance cannot be overemphasized. It is helpful in a crude comparison of strategic forces but it cannot be used without other more detailed indicators to draw basic conclusions concerning the adequacy of U.S. strategic forces.

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INDICATOR: COUNTER MILITARY POTENTIAL (CMP)

DESCRIPTION OF INDICATOR

CMP is a measure of effectiveness of a nuclear weapon against hard point targets. It is calculated by $[\text{Yield}]^{2/3}/[\text{CEP}]^2$. The CMP of a force is the sum of the CMP of the individual weapons in the force.

SIGNIFICANCE OF INDICATOR

CMP of a nuclear weapon is directly related to its kill probability against a point target of a given hardness. The aggregation of CMP of individual weapons to obtain an overall force CMP can be used as a rough comparison of the effectiveness of different forces against an amorphous hard point target structure. It is, however, only a crude indicator of such effectiveness, similar in applicability to hard point targets as EMT is to soft area targets.

LIMITATIONS OF INDICATOR

Since CMP emphasizes accuracy through the $[\text{CEP}]^2$ term, uncertainties in accuracy lead to large uncertainties in CMP. It is difficult to determine with confidence the CEP of one's own systems and nearly impossible to determine the accuracy of Soviet systems. In addition, the emphasis on accuracy can be misleading. For example, a strategic bomber with a good bomb/nav system, carrying gravity bombs, will appear to have high effectiveness even if its penetration capability is limited. In addition, each bomb dropped from a B-1 has a theoretical CMP of nearly 700. This is more than six times the CMP required to destroy a 1,000-psi target with 97 percent probability. Consequently the lumping together of individual CMPs to obtain an overall force CMP can be misleading. It can overestimate the effectiveness of a strategic force.

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ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The uncertainty in CMP of an individual weapon is compounded by rather large uncertainty in both its yield and CEP. For a force, this uncertainty is further compounded by the uncertainty associated with individual elements.

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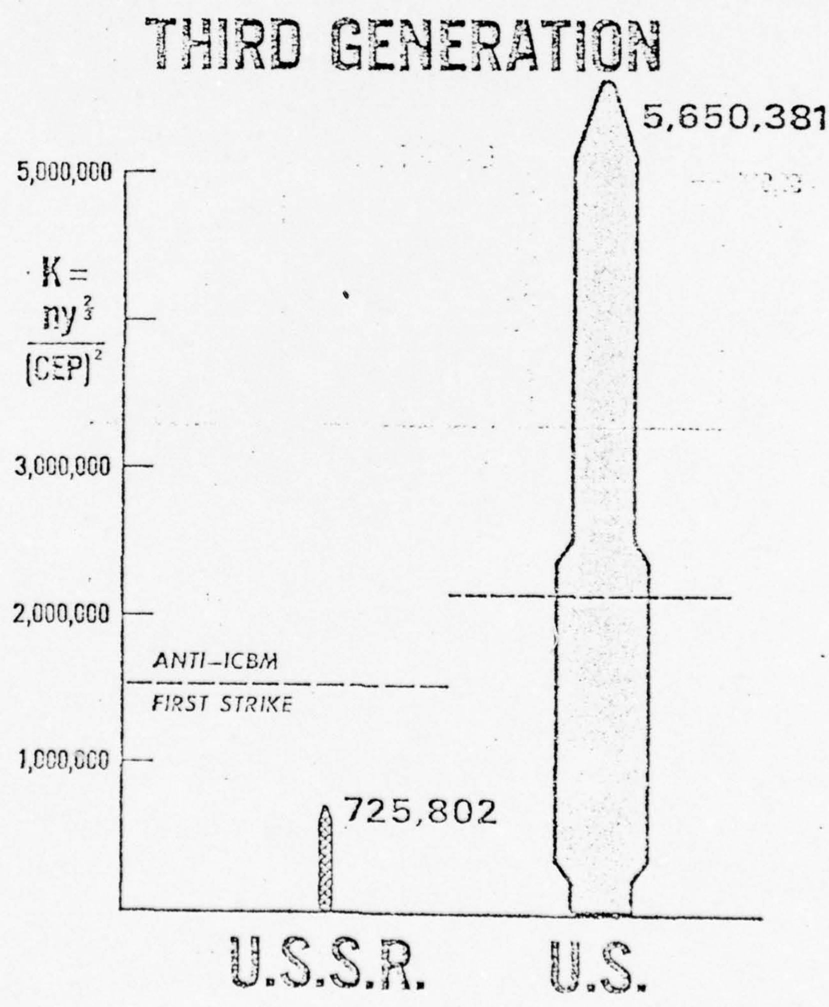
SAMPLE USE OF INDICATOR



Source Document: Statement of Rep. Robert L. Leggett before the House Subcommittee on International Security and Scientific Affairs, the Vladivostok Accord: Implications in U.S. Security, Arms Control, and World Peace, 94th Congress, 1st Session, June 24, 25 and July 8, 1975.

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DISCUSSION

The author calculates the CMP in the ICBM and SLBM forces of the two sides during a time frame in which U.S. missiles achieve 0.02-nm CEP due to MARV while Soviet ICBMs achieve 0.1-nm CEP and their SLBMs have 0.5-nm CEPs. This results in a huge U.S. CMP advantage in comparing the strategic ballistic missile forces of the two sides. He goes on to calculate a fourth generation force CMP, attributing MARV-like CEPs to Soviet ballistic missiles. He concludes that MARV along with possible ASW developments will give both sides a destabilizing first strike capability. He urges that restraint be exercised in the MARV program and that limitations on throw weight and numbers are less important than qualitative limitations in SALT.

COMMENT ON THE USE OF THE INDICATOR

The author succumbs to the most obvious misuse of the CMP indicator in drawing his conclusions. The combination of yield and accuracies (primarily accuracies) result in enough CMP per warhead to destroy two targets of 1,000-psi hardness for U.S. SLBM warheads and to destroy nine such targets for each ICBM warhead. Since any one warhead is likely to destroy only one hard target, regardless of its high accuracy, the CMP index has little realistic utility in the comparison made by the author. The author uses the overall ballistic missile force CMP to draw wide ranging conclusions which miss the central issues. In fact, a responsible case can be made for pursuing qualitative accuracy improvements in order to minimize collateral damage in limited attacks on military targets. The fact that is most damaging to the author's conclusions, however, is that limitations in SALT on accuracy improvements have been found to be completely unverifiable.

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SAMPLE USE OF INDICATOR

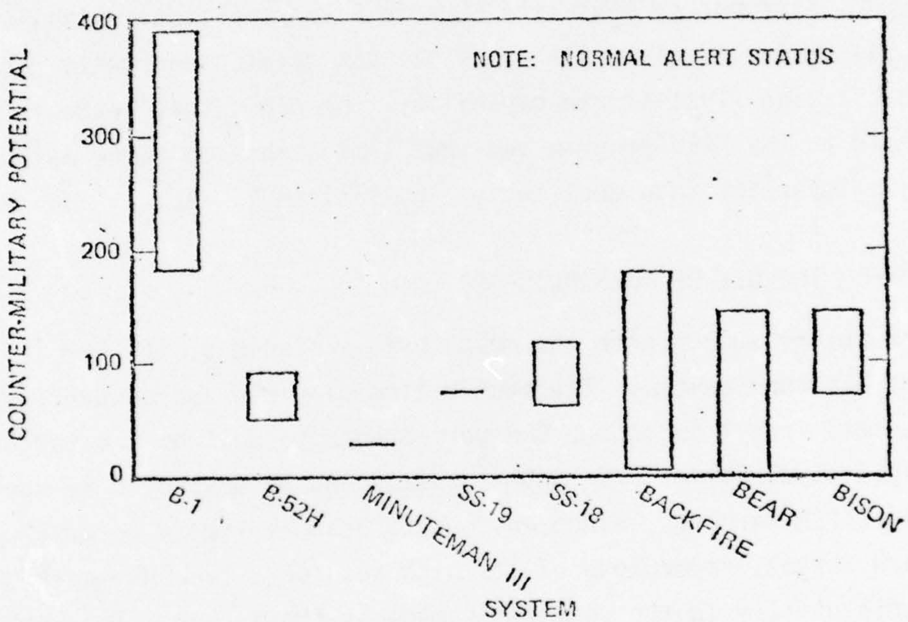

FIGURE 10 (S). AVERAGE DELIVERED COUNTER-MILITARY POTENTIAL ({YIELD}$^{2/3}$ / {CEP}^{2}) PER SYSTEM (NORMALIZED TO A MAXIMUM OF 108/WEAPON – P_{ssk} = 0.97 FOR 1000 psi TARGET/WEAPON) (U)

SPC152-3-11-76-11

Source Document: SPC Report No. 249, "Analysis of Strategic Bomber Measures", Stanley B. Kottock, March 1976.

DISCUSSION

The author compares the CMP of various strategic delivery vehicles with nominal weapon loadings. He counts the CMP of each weapon so that the amount in addition to that required to destroy a 1,000-psi target (with 97 percent probability) is not credited to the total. This assures that credit for

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only one target is given to each weapon used against hard point targets. In addition, he assigns realistic factors which degrade the effectiveness of bombers in relation to that of ballistic missiles by virtue of the bomber's vulnerability to an SLBM attack and its chance of loss during penetration of air defenses.

COMMENT ON THE USE OF THE INDICATOR

The author vividly reveals that the use of CMP to portray the effectiveness of heavy bombers against hard point targets tends to overestimate their utility relative to ICBMs in a counterforce roll. This is true even when realistic factors are taken into account for the degradation of the bomber's delivery role. In fact, this is a reversal of the conventional view of bombers as counterforce systems, a role in which they are severely limited due to the time required to reach the target.

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INDICATOR: ICBM THROW-WEIGHT

DESCRIPTION OF INDICATOR

The throw-weight of an ICBM is the weight of those devices which are part of the delivery package at the end of the boost phase of the ballistic missile. It is the useful weight at the end of the boost phase, which contributes to delivering the RVs to selected aim-points at intercontinental range. For MIRVed ICBMs it includes the weight of the RVs, pen aids, bus, dispensing mechanism, guidance system, and fuel for the bus. For single RV ICBMs and ICBMs with MRVs, it includes the weight of the RV or RVs, pen aids, dispensing mechanism, and guidance system.

SIGNIFICANCE OF INDICATOR

The throw-weight of an ICBM is a general measure of the potential of the system to deliver useful payload or destructive power to intercontinental range. It is a general measure of the capacity of a system within a given level of technology to be exploited for military purposes.

LIMITATIONS OF INDICATOR

The throw-weight of an ICBM is not a direct indicator of its destructive potential or military utility. It does not delineate the number of RVs, their yield or accuracy, nor does it display the reliability of the system. All of these factors are necessary to determine the effectiveness of the ICBM in destroying various elements in a target structure (especially hard point targets). Consequently, in order to use ICBM throw-weight in an estimate of system effectiveness, assumptions must be made concerning the technological sophistication of the system's guidance package, RV reentry characteristics, warhead yield-to-weight ratio, and reliability (pre-flight, boost, reentry).

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ESTIMATE OF THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

It is estimated that the uncertainty in the value projected for the throw-weight of a Soviet ICBM is $\pm$ ______ percent within _____ years of the first _____ flight tests.

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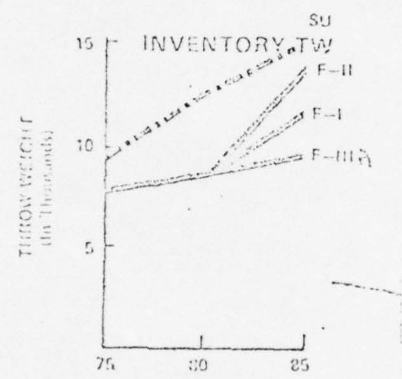
PERCEIVED BALANCE
(2400 SNDV/1320 MIRV LEVEL)



SAMPLE USE OF INDICATOR

Source Document: Strategic Forces Review, E. C. Aldridge, Jr., OASD(PA&E), January 10, 1975, SPC Control No. 75-162.

DISCUSSION

The strategic ballistic missile (ICBM and SLBM) trend analysis displaying force throw-weight versus calendar year, taken from the source document, was used to draw the following conclusions. The U.S. has sufficient force options (F-I, F-II, F-IIIA) within the constraints imposed by the Vladivostok accord that:

- No major changes are <u>required</u> in U.S. strategic forces as a result of the agreement.
- The U.S. can accomplish its strategic objectives with forces in the range of 2,100 - 2,400 SNDVs.

COMMENT ON THE USE OF THROW-WEIGHT INDICATOR

The subject trend analysis used alone would not be sufficient for a responsible decision maker to draw the above conclusions unless he subjectively discounted the importance of a Soviet advantage in strategic missile force throw-weight. The author based his conclusions on the following trend

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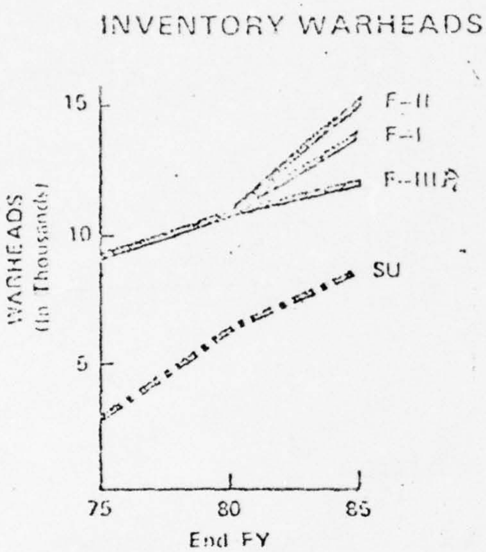
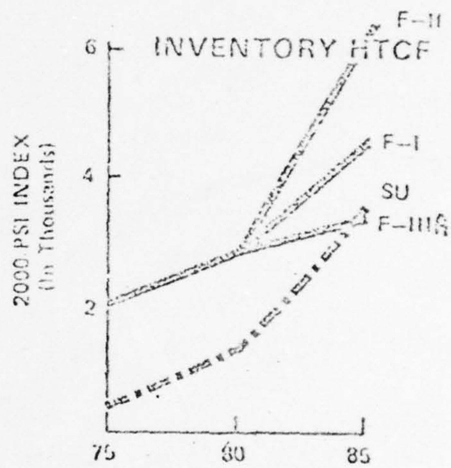
analyses which reveal offsetting U.S. advantages in number of warheads and hard target counterforce capability.





While ICBM (or combined ICBM and SLBM) throw-weight is a good general index of potential force capability, it requires assumptions on the level of technological sophistication in order to draw conclusions regarding the comparative effectiveness of the opposing strategic missile forces. Observe that the conclusions drawn from the last two figures are quite sensitive to assumptions about fractionation, accuracy, yield, and reliability.

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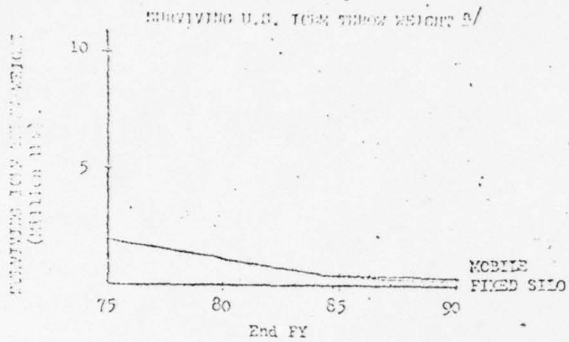
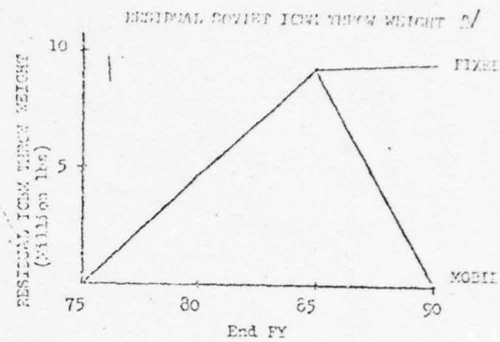
IMPACT OF MOBILITY ON SURVIVING/RESIDUAL THROW WEIGHT





SAMPLE USE OF INDICATOR

Source Document: Strategic Forces Review, E. C. Aldridge, Jr., OASD(PA&E), January 10, 1975, SPC Control No. 75-162

DISCUSSION

The subject source document did not draw conclusions from the trend analyses shown above but the data suggests obvious conclusions. They are:

- The Soviets can draw down surviving U.S. ICBM throw-weight to low levels by 1985,
- If the U.S. deploys shelter based mobile ICBMs, the Soviets can impose the same low level of U.S. surviving ICBM throw-weight but they must expend a large fraction (up to 100 percent) of their ICBM throw-weight to do it compared to a large Soviet residual for the case where the U.S. retains its fixed ICBM force.

COMMENT ON THE USE OF THROW-WEIGHT INDICATOR

If one attributes to the Soviets the technological capability within the next decade to effectively attack both fixed and mobile ICBMs, and if one accepts throw-weight as the important measure of the effectiveness of the residual Soviet ICBM force, the conclusions support a judgment to develop and deploy mobile ICBMs. Such judgments and conclusions should, however, take into account whether or not:

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- The trend analysis was based on a Soviet force optimized for attacking fixed ICBMs (consequently wasteful in attacking many 300 psi shelters),
- All factors, including interaction effects, were taken into account in the attack on fixed ICBMs,
- Realistic values were used for Soviet ICBM accuracy and reliability,
- The Soviets are judged to have a technology base capable of changing the characteristics of the attacking force to counter a shelter based mobile deployment in a timely fashion.

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INDICATOR: COMBINED STRATEGIC BALLISTIC MISSILE AND BOMBER THROW-WEIGHT

DESCRIPTION OF INDICATOR

The throw-weight/payload combination of the entire strategic force is often used as an overall measure of the strategic balance. Such calculations sum the throw-weight of individual ICBMs and SLBMs in the force and add in the equivalent throw-weight or payload of each strategic bomber. The contribution of strategic bombers to the total is often diminished by factors which account for the dead weight of nuclear weapons used as bomber armament and the degradation of the bomber's effectiveness in penetrating air defenses.

SIGNIFICANCE OF INDICATOR

This indicator is a gross measure of the potential destructive power of a total force. If a level of technology is assumed, the effect of this potential can be determined in specific scenarios in which particular weapon characteristics determine the outcome of nuclear exchanges or influence perceptions of the strategic balance.

LIMITATIONS OF INDICATOR

The values assigned to the indicator can be distorted by the contribution of strategic bombers. Various authors will assign to bombers values extending from the total weight the bomber can carry in bombays and on external mountings to a miniscule fraction of that weight, depending upon the author's viewpoint. For example, a B-52 has been assigned payloads from 60,000 lb to 5,000 lb in various studies. This is a consequence of the fact that the

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indicator attempts to measure two entirely different species of weapon system, ballistic missiles and strategic bombers, with a common index. The different nature of these systems, their different roles, and the differences in the defenses opposing them render such an index difficult to evaluate and of uncertain utility in evaluating the strategic balance. It does, however, provide a gross measure of the capability of the strategic forces.

ESTIMATE OF THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The uncertainty in a value of this indicator is a combination of the uncertainties in its composite parts. Uncertainty in the throw-weight and numbers of ICBMs and SLBMs is relatively low, as is the total load carrying capacity of strategic bombers. The uncertainty in the factors assigned to bombers to account for their degraded effectiveness possibly introduces larger errors than those due to other causes.

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SAMPLE USE OF INDICATOR

Source Document: "How to Look at the Soviet-American Balance," Les Aspin, Foreign Policy Magazine, Spring 1976.

Quote: "But the simple fact is that the United States has a commanding lead of 27 million pounds to 12 million pounds when total missile throw-weight and maximum bomber payload are combined."

COMMENT ON THE USE OF THE INDICATOR

In order to arrive at a 27 million pound throw-weight/payload for U.S. strategic forces, the author would have to assign approximately 50,000 lb of payload to each U.S. heavy bomber. This is near its maximum load carrying capacity. This assigns an effectiveness to such a bomber of about three times that of an SS-18 or twenty times that of a Minuteman III. Such an optimistic view of bomber effectiveness would not be warranted even if each system had similar survival circumstances and penetration capabilities. The nature of the bomb/missile loading of a heavy bomber, especially one loaded with short range missiles to attack air defenses, requires a high fraction of structural (and fuel) weight to warhead weight. This virtual attrition directly degrades the bomber's effectiveness and should be accounted for in the payload assigned to it. In addition, the U.S. heavy bomber (but not ballistic missiles) must penetrate thick Soviet defenses which will diminish the bomber payload actually delivered on target. This should also be accounted for when lumping bomber payload in with ballistic missile throw-weight

The degradation factors used for heavy bombers are arbitrary but necessary in calculating values of the indicator. The following figure depicts a result of such a calculation.

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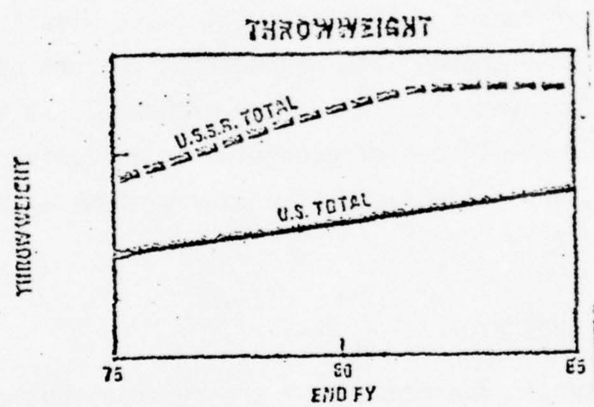
PROJECTED INVENTORY U.S./U.S.S.R.
(2400 SNDV/1320 MIRV LEVEL)



Source: FY77 U.S. Defense Budget Perspectives, Donald Rumsfeld, Sec Def, 26 February 1976.

The bomber degradation factors for the above calculation are not known but presumably they are on the order of .2 to .3 to assign about 10,000 to 15,000 pounds to a heavy bomber. Disagreement will always exist on values assigned to these factors because their effect dominates the result. Some realistic factor should be assigned, however, in order that the contribution due to heavy bombers is not overstated.

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INDICATOR: COMBINED STRATEGIC FORCE THROW-WEIGHT BEFORE AND AFTER AN EXCHANGE

DESCRIPTION OF INDICATOR

This indicator sums the strategic ballistic missile throw-weight and bomber payload (with appropriate degradation factors applied) of the strategic forces before and after a nuclear exchange. It assumes a given level of technology for the forces of each side by assigning values to the number, yield, accuracy, and reliability of weapon systems as well as hardness values of the targets.

SIGNIFICANCE OF INDICATOR

This indicator is one measure of the residual nuclear capability on both sides after a nuclear exchange. It addresses a most extreme possibility, that of an all-out nuclear exchange, hence is a bounding case for the perception of the stability of the strategic balance. If it shows that a side can alter the balance in its favor by striking first, an incentive for such action could be perceived by either side, thereby affecting their internal decisions. If it reveals that a side can maintain or increase its initial advantage by attacking first, each side could draw conclusions concerning the possibility of perceptions of the balance being used for political leverage in contentious foreign policy areas.

LIMITATIONS OF INDICATOR

Since the indicator measures a dynamic process, it is subject to judgements concerning the values of the input parameters. Seldom is there sufficient unanimity in the description of the threat and the vulnerability of the target structure to provide a result that is unchallengable on the

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basis of the assumptions used and the values assigned to the input parameters. In addition, the results and conclusions drawn therefrom may be quite sensitive to which side strikes first. Using consistent assumptions, however, trends of this indicator over time along with other indicators should form a reasonable basis for drawing conclusions regarding a most conservative characterization of the strategic balance.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The uncertainties generated by the assumptions regarding input values and due to the exchange model itself far exceed the uncertainties associated with measuring the values for Soviet systems. The former result from subjective judgements, the latter from the process of taking a measurement. Consequently, little hope exists that the output of such an exchange calculation accurately models reality.

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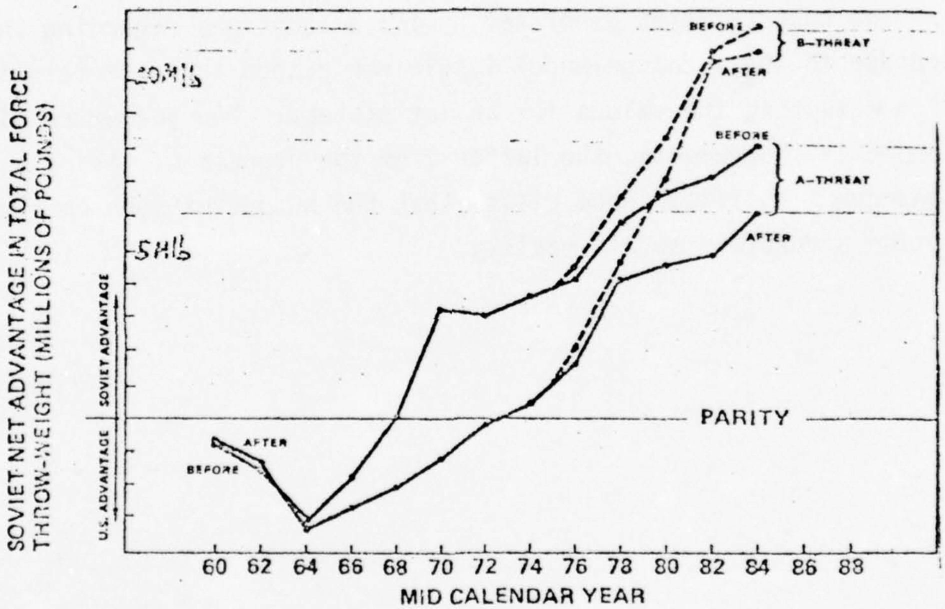
SAMPLE USE OF INDICATOR

Soviet – U.S. Throw-Weight Differentials



[16] A B-52 has been assigned an equivalent throw-weight of 10,000 lbs. and a B-1 about 19,000 lbs. The SRAM air-to-surface missile has a yield about equal to that of a Minuteman III warhead; hence, for every three SRAMs carried by a bomber, that bomber is given a throw-weight equivalent equal to the throw-weight of one Minuteman III. Laydown bombs are assumed to have roughly the yield of Minuteman II; hence, for each laydown bomb carried by a bomber it is given a throw-weight equivalent equal to the throw-weight of a Minuteman II. The alert bomber force is assumed to be 40 percent of the B-52 inventory and 60 percent of the B-1 inventory, degraded to incorporate penetration factors.

Source Document: "Assuring Strategic Stability in an Era of Détente," Paul H. Nitze, Foreign Affairs, Vol 54, No. 2, January 1976.

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DISCUSSION

The author reviews the historical perspective of U.S. nuclear strategy and its supporting military posture. He describes the U.S. deterrent posture of the 1960s and early 1970s based upon mutual assured destruction and discusses recent Soviet increases in strategic offensive power and the impact of an emerging Soviet civil defense program. He questions the clarity of the U.S. deterrent and urges consideration of a more crucial test, that of a large-scale nuclear exchange in which one side seeks to destroy as much of the other side's striking power as possible, in order to leave itself in the strongest possible position after the exchange. He reasons that such a strategy must be taken into account.

COMMENT ON THE USE OF THE INDICATOR

The trend analysis based on the total force throw-weight indicator reveals that the Soviets are developing not only an inventory advantage but could, with qualitative improvements in their forces, reach a position in which they would be even more advantaged relative to the U.S. by striking first. Such results are, of course, highly sensitive to the assumed force characteristics as well as to the manner in which the responding attack is conducted. A reasonable approach was used by the author. The analysis does not reveal the whole picture, however, since one's conclusions might be altered slightly if the trend displayed a similar nature for a U.S. first strike.

The author does, however, recognize the limitations of such a complex indicator by observing that:

- If the absolute level of the forces remaining to the weaker side is high, and if it continues under effective command and control, and is comprised of a number of RVs adequate to threaten a major portion of the other sides military and U/I targets, continued effective deterrence exists even if the throw-weight ratios are unfavorable,
- Although assumptions have been made in the underlying data and calculational model, the methods are self-consistent over time. Thus they reveal a valid trend.

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INDICATOR: NUMBER OF ABM MISSILE LAUNCHERS, RADARS, AND PHASED ARRAY RADARS

DESCRIPTION OF INDICATOR

Each of these indicators is described by a number associated with visual evidence of the existence of that particular system in a deployed status.

SIGNIFICANCE OF THE INDICATOR

Since the ABM treaty and its Protocol have limited each side to one ABM site with a maximum of 100 interceptors and six ABM radar complexes, very little significance is attributed to this actual number of such systems deployed by either side. This is due to the fact that such low level deployments give neither side a capability for significant area or ICBM launch site defense.

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INDICATOR: PRODUCT OF POWER AND APERTURE OF AN ABM RADAR AND THE AVERAGE VELOCITY OF THE INTERCEPTOR TO THE THIRD POWER

DESCRIPTION OF INDICATOR

This indicator is the mathematical product of three physical quantities associated with an ABM system, the mean radiated power of the radar, the effective radar antenna cross sectional area, and the average velocity of the interceptor raised to the third power. That is, PAV^3. It is in units of watt-meter^2 [ft/sec]^3.

SIGNIFICANCE OF INDICATOR

The interaction between the characteristics of the ABM radar and the interceptor is important in determining the capability of the system. For a given defended radius and given incoming RV characteristics (i.e., radar cross-section and ballistic coefficient) a plot of the power aperture product against the average velocity of the interceptor to the intercept point is a straight line (for a reasonable range of offensive systems). This relationship allows one to determine the performance of existing ABM (and air defense) systems when defending against a given offensive system as well as the tradeoff in radar/interceptor design parameters when evaluating the ABM system against a particular threat. It has been observed that the straight line relationship (against an RV with given radar cross section and ballistic coefficient) can be approximated by the function, PAV^3 = const or $PA \alpha V^{-3}$ approximates the linear relationship of PA with V over the region of interest for a given incoming RV. Consequently, the expression PAV^3 = constant approximates a relationship between the radar and interceptor which completely determines the capability of an ABM system. Plots of this parameter can be used to gauge the effectiveness of the ABM system against various offensive systems.

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LIMITATIONS OF INDICATOR

The indicator is a surrogate for an approximation based upon a simplified model of the ABM/offensive system interaction. The model is constrained to test the effectiveness of the defense against a single attacker with no penetration aids. Problems associated with various penetration aids, offense and defense fratricide, battle space, multiple reentry vehicles, maneuvering reentry vehicles, nuclear effects, reliability, and leaking are not taken into account. In addition, the power of the indicator in determining in an approximate way the basic capability of an ABM system is diminished by the relative complexity of the model and the resulting calculations.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

Since the model is a simple approximation of a real engagement, such quantities as the average interceptor velocity are asserted, not measured. Consequently the vast uncertainty introduced by the model far exceeds uncertainties introduced by estimates of the power aperture product.

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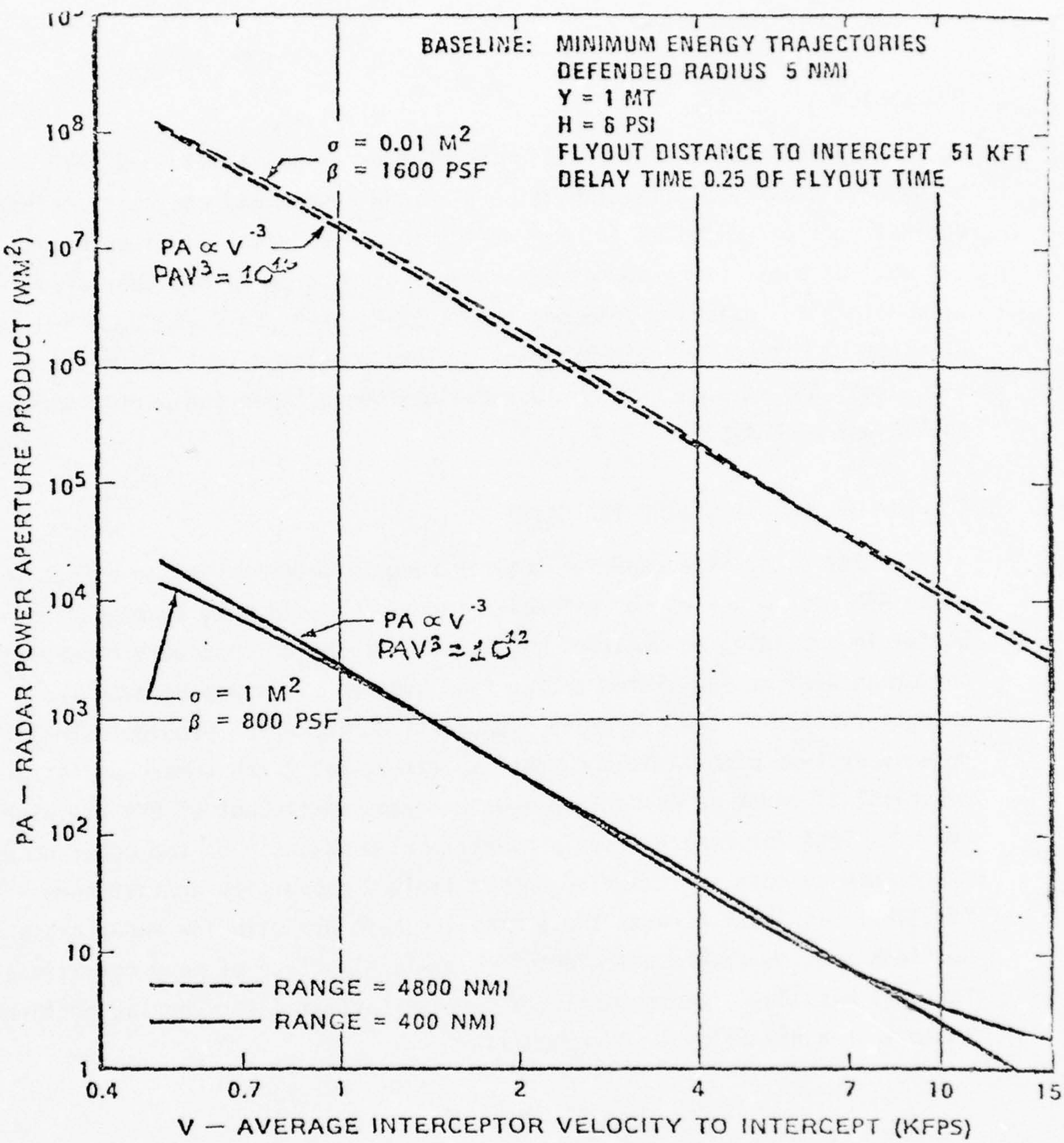

FIGURE 3 (U). BALLISTIC MISSILE TERMINAL DEFENSE SEARCH RADAR REQUIREMENT AS A FUNCTION OF INTERCEPTOR VELOCITY (U)

Source Document: Comparison of ABM and ATBM Requirements, SPC report No. 224, H. Dern, et al, 30 September 1975.

DISCUSSION

The authors attempted to determine whether or not a value of PAV^3 could be used to clearly distinguish between an ABM system and one which defends against tactical missiles (ATBM). Using the theoretical plots as shown (as well as plots using actual offensive system parameters), they displayed data points for existing defenses (Hawk, SA-2, SA-4, SA-5, SA-6, SAM-D, AEGIS/SM-2, site defense, MSR/sprint). They concluded that the model did not reveal the existence of a clear delineation between the performance of an ABM and ATBM system.

COMMENT ON THE USE OF THE INDICATOR

The indicator is a powerful tool in roughly determining the effectiveness of an ABM system against an offensive threat. It did not, however, prove useful in providing an abstract measure of a technical boundary between the performance of an ABM system and an ATBM system. This was because the characteristics of the offensive system RVs dominate the problem. That is, defense systems with limited capability ("tactical") can intercept "strategic missiles" if radar cross-section and the drag coefficient of RVs are high, which is true for many currently operational missiles. On the other hand, these same defense systems have only a limited capability against some "tactical missiles" because these missiles have RVs with low radar cross sections and low drag coefficients, which is also true of many operational tactical missiles. Consequently, a defense optimized for the latter threat could have a significant ABM capability.

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INDICATOR: NUMBER OF RADARS, INTERCEPTORS, SAMs

DESCRIPTION OF INDICATOR

Each of these indicators is a quantitative measure of a feature which contributes to a capability to detect, track, and destroy enemy aircraft. The number of radars is the number of early warning and ground control intercept radars deployed. The number of interceptors is the number of aircraft with an intercept capability deployed with the air defense forces. The number of SAMs is the number of surface to air missiles associated with the number of launchers at deployed SAM sites. It does not include a total inventory of missiles.

SIGNIFICANCE OF INDICATOR

The number of interceptors and radars is a gross measure of the area defense capability against enemy bombers. It gives a general idea of whether or not sufficient forces are available to cover likely approach routes and to protect territorial regions from attack. The number of SAMs is an indicator of the extent of the point defense capability of the air defense forces. The number of missiles and sites located around high value targets is an indication of the difficulty the bomber will encounter in attacking them. The indicators when used together provide a general quantitative measure of the extent of the emphasis a side places on defending itself against attack by bombers. They are the simplest of indicators in this measure, thus easily understood. Their shortcomings, however, may not be as obvious.

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LIMITATIONS OF INDICATOR

None of these indicators, alone or in aggregation, provides a true measure of the effectiveness of the air defense forces. Qualitative characteristics such as radar and interceptor performance against a specific penetrating target must be evaluated in order to judge the true area defense capability. Similar qualitative characteristics of the radar-missile combination must be compared to bomber characteristics in determining the effectiveness of the SAMs in providing point defenses. The amount of geographic area to be defended and the number and geographic dispersion of the targets to be defended are also important parameters of the air defense problem which are not taken into account by the quantitative indicator being addressed. One of the most important aspects of the bomber/air defense engagement outcome is the effectiveness of electronic countermeasures and electronic counter countermeasures. The quantitative indicator being discussed does not, of course, account for this important aspect.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

Since each numerical component of the overall quantity is a sizeable physical entity, easily recongnizable, each is determinable with relatively high precision.

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SAMPLE USE OF INDICATOR

SOVIET AIR DEFENSE

Soviet strategic air defense is by far the most massive and expensive in the world, consisting of some 550,000 troops, more than 5,000 radars for early warning and ground control intercept, some 2,600 fighter-interceptors, and almost 12,000 strategic surface-to-air missiles.

The Soviet air defense interceptor force has all-weather capability and can intercept targets at medium or high altitudes. Low intercept capability is limited and lags behind that of USAF. The latter deficiency is being corrected to a degree through the introduction into the inventory of the Su-15 Flagon-E, which is credited by US experts with "a moderately good intercept capability at low altitude." Flagon-E, which entered the interceptor force along with the MiG-25 Foxbat-A in 1975, has new and more powerful turbojet engines to boost both speed and range, as well as advanced air-to-air missiles coupled to upgraded avionics. The aircraft is being equipped with a cannon, presumably to give it a weapon that is less vulnerable to countermeasures.

Other aircraft of the Soviet strategic air defense force include MiG-17 Fresco, MiG-19 Farmer-B/E, Su-9 Fishpot-B, Yak-28P Firebar, Tu-128P Fiddler, Su-11 Fishpot, and Su-15 Flagon-A and -D.

SOVIET/US STRATEGIC AEROSPACE DEFENSE FORCES, 1972–74

All figures are from *The Military Balance* (1972–73 through 1975–76 editions).

In assessing the overall balance between Soviet and US strategic nuclear capabilities, the bomber forces of each side must be evaluated in relation to the aerospace defense forces of the opponent. Although the US holds a substantial lead in long-range bombers, Soviet aerospace defense forces are many times larger than those of the US.

	Interceptors		Strategic Surface-to-Air Missiles		Antiballistic Missile Launchers	
Year	USSR	US[a]	USSR	US[b]	USSR	US
1972	3,000	593	10,000	839[c]	[illegible]	0
1973	2,900	585	10,000	481[d]	[illegible]	0
1974	2,650	532	9,800	261	64	0
1975	2,550	374	12,000	0	64	0[e]

[a] Includes both Regular and Air National Guard units.
[b] Includes both Regular and Army National Guard units.
[c] Includes 21 Nike-Hercules batteries and 5 Bomarc-B batteries.
[d] Nike-Hercules only, 1973 and 1974.
[e] The US Safeguard BMD system that became operational in October 1975 has been closed down by congressional denial of operating funds.

Source Document: "The Soviet Juggernaut: Racing Faster than Ever," Edgar Ulsamer, Air Force Magazine, March 1976.

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DISCUSSION

The author cites the superior number of Soviet radars, interceptors, and SAMs as an example, along with many others of Soviet military superiority or momentum toward military superiority over the United States in a vast range of indicators of the military balance.

DISCUSSION OF THE USE OF THE INDICATOR

The author correctly points out that, in assessing the overall balance between U.S./Soviet strategic nuclear capabilities, the bomber forces of each side must be evaluated in relation to the air defense forces of the opponent. He goes on to say that, although the U.S. holds a substantial lead in long-range bombers, soviet air defense forces are many times larger than those of the U.S.

Such observations are certainly true but they are based on much too limited evidence to accurately assess the true balance. The ability of existing or planned U.S. bombers to penetrate existing or projected air defenses must be determined before this assessment can be made. This requires a comparison of the quantitative and qualitative features of the bomber force in its effectiveness against the quantitative and qualitative features of the opposing air defenses. A simple comparison of the numbers of air defense components does not give an accurate portrayal of the appropriate balance. It is, however, a useful indicator when used with other features to portray the balance.

SAMPLE USE OF INDICATOR

FIGURE 1.—*United States/Soviet numerical balance*

[See Annex A for details]

U.S. SUPERIORITY		SOVIET SUPERIORITY	
STRATEGIC NUCLEAR			
Bombers ALCMs	MIRVs Warheads	ICBMs SLBMs	SLCMs Air defense

	1965			1975			
	United States	Soviet	United States (difference)	United States	Soviet	United States (difference)	Net U.S. change
STRATEGIC DEFENSIVE							
Personnel [9]	120,750	500,000	−379,250	25,100	600,000	−574,900	−196,850
Army	23,050	400,000	−376,950	900	500,000	−499,100	−122,150
Navy	3,950	0	+3,950	1,200	0	+1,200	+2,750
Air Force	93,750	100,000	−6,250	23,000	100,000	−77,000	−70,750
ABM missiles [10]	0	0	([10])	100	64	+36	+36
SAM launchers [11]	2,694	8,900	−6,206	330	9,500	−9,170	−2,964
Interceptors [12]	1,113	3,800	−2,687	396	2,700	−2,304	+383

Source Document: The United States/Soviet Military Balance, John M. Collins and John S. Chwat, Library of Congress Congressional

DISCUSSION

The author uses a compendium of numerical indicators to display the overall U.S./Soviet military balance. If certain numerical quantities associated with a category of weapon system (classified according to role) show a higher number for the Soviets than the U.S., he asserts a Soviet superiority for that category.

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COMMENT ON THE USE OF THE INDICATOR

The author makes the following observation relative to the data displayed above:

> This country, in conjunction with Canada, maintained the world's most comprehensive air defense system in the mid-1960s. Ten years later that accumulation has been cut to the bone. Only 12 dedicated fighter-interceptor squadrons, half in the Air National Guard will remain after phaseouts are complete. All SAM batteries once assigned to the Army Air Defense Command were inactivated in Fy 1974. By way of contrast, the Soviet air defense shield currently contains 2,700 interceptor aircraft and 12,000 SAMs. That agglomeration which is larger than ours at its apogee, is constantly being improved.

Such comparisons are among the poorest possible choices for depicting the appropriate U.S./Soviet military balance. The use of the indicator to directly compare U.S. and Soviet air defense forces is of questionable validity. In fact, it can mislead. The important criterion is one which displays how the opposing bomber/air defense forces interact. If the U.S. bomber force, current and projected, can penetrate current and projected Soviet air defenses as effectively as the Soviet bomber force can penetrate U.S. air defenses, a quite different perception of the balance could ensue. In any event, factors such as ECM and ECCM effectiveness, geographic expanse, topography, location of high value point targets, and qualitative characteristics of the bomber, the radars, the interceptors and SAMs could be as influential in the outcome of an engagement as the raw numbers of bombers and/or air defense components. Consequently, a direct comparison of the air defenses of each side is of little value.

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INDICATOR: NUMBER OF CIVIL DEFENSE PERSONNEL

DESCRIPTION OF INDICATOR

This indicator is the number of people actively involved in some aspect of the civil defense program. For the Soviet Union, the civilian component is organzied on a compulsory basis among workers in municipal services, industry, transportation, communications, public safety and health, collective farm personnel, etc. Estimates of 23 to 30 million of these workers serve in civil defense formations. In addition, an undetermined number of military personnel serve in the civil defense force. For the U.S., civil defense is carried out primarily by state and local emergency preparedness agencies (law enforcement, fire fighting, and rescue squads, etc.). These agencies are assisted in the organization and planning activities by 113 National Guard, Army Reserve, and other service components, both active and reserve. Normally, all military forces within CONUS are considered potentially available to provide assistance.

SIGNIFICANCE OF INDICATOR

The number of personnel actively involved in some part of civil defense planning is a rough measure of the extent of the side's civil preparedness in case of a nuclear attack. It is an indirect measure of the possible scope of plans to protect the population in the event of a nuclear attack. As such, it is a crude measure of the perceived importance of civil defense in a side's overall nuclear posture.

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LIMITATIONS OF INDICATOR

The indicator is a crude and indirect measure of the scope of the plans for protecting population in the event of a nuclear attack. It is not at all closely related to the effectiveness of such plans. The effectiveness of the plan is the true measure of the value in having an active civil defense posture and a determinant of whether or not it can be incorporated into the overall nuclear strategy.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The value of the indicator can only be estimated within about $\pm$ 50 percent because of the problem of identifying the active parts of a civil defense plan, the relative priority of these planning activities in various geographic regions, the amount of activity actually carried out, the inertia associated with plans which are seldom exercised.

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SAMPLE USE OF INDICATOR

Source Document: Soviet Civil Defense, T. K. Jones, Testimony Before the Panel of the Subcommittee on Investigations, House Armed Services Committee, 3 March 1976.

Quote: "The permanent, full time staff of the Soviet civil defense organization now numbers 72,000. In time of crisis, the permanent civil defense staff would be augmented by the Soviet's very large cadre of trained people with skills needed in the evaluation areas themselves. Massive summer exercises are conducted by DOSAAF which now numbers some 10 million members and is headed by a Marshal of Aviation. In June and July 1975, 23,000,000 Soviet youths were in the countryside participating in massive "military sports" games. These games included survival training, identification of contaminated areas, and determining how to go around or through them in accordance with safety rules."

COMMENT ON THE USE OF INDICATOR

The author, during a comprehensive review of Soviet civil defense plans, uses the above information to support a conclusion that, "probably the most desirable and least costly step which could be taken to counter the effects of the Soviet civil defense preparations would be for the U.S. to increase its level of civil defense preparedness."

During the course of his testimony, the author cited various details of Soviet civil defense planning. These features touched nearly every facet of society; from plans to evacuate urban areas to plans to use the laborers on collective farms to indoctrination of school children in civil defense plans. Indeed if such comprehensive plans are actually in effect, one could consider every Soviet citizen to be actively engaged in a civil defense program at one time or another. Other authors, however, use estimates

based on percentages of a particular societal segment to arrive at a value of the indicator. Dr. Leon Goure has used (testimony before same subcommittee on 2 March 1976) an estimate of 70 percent of the industrial workers (23 million) attributed to an active role in civil defense formations. He does not estimate military participation.

Such tabulations only serve to show that the number of Soviet participants in civil defense plans is subject to huge variations depending upon each author's judgement of the scope of the plan itself. Since the effectiveness of the plans are not subject to test by the opponent (nor by the planner for that matter), very little objective information can be derived from estimates of the magnitude of the number of participants.

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INDICATOR: CIVIL DEFENSE FUNDING

DESCRIPTION OF INDICATOR

Civil defense funding is the total amount of federal funds allocated each fiscal year to the organization and administration of civil defense plans. It is a line item in the U.S. defense budget. It does not include state and local funding for agencies and activities supporting programs primarily required for natural disaster preparedness which are also applicable to nuclear disaster preparedness.

SIGNIFICANCE OF INDICATOR

Civil defense funding is a broad gauge measure of the extent of support of a civil preparedness program. It provides an insight into the relative importance attributed to civil defense compared to competing programs in a given defense budget. Trends in civil defense funding as a fraction of the defense budget are useful in determining any change in attitude towards the importance of civil defense in a nation's strategic posture.

LIMITATIONS OF INDICATOR

Since the Soviet Union maintains secrecy on its civil defense budget, we have no firm evidence of their civil defense funding. A large part of it is buried in the budgets of municipalities, factories, farms, etc. Estimates based on the U.S. dollar cost of planning and programs which appear in the open Soviet literature are plagued with the same problems as mentioned in the economical indicators section. They tend to overestimate due to the different price structure within the Soviet economy. Consequently, this is a poor indicator to use in comparing U.S. and Soviet civil defense programs.

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Comparison of year to year funding of either the U.S. or the Soviet civil defense programs, using consistent methodology, can be useful, however, in determining the relative importance attributed to civil defense by that nation.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF INDICATOR

Due to the lack of hard evidence, estimates of Soviet civil defense funding are subject to large error. It is reasonable to expect that the estimate can vary by a factor of _____ from the actual value due to errors introduced by the methodology.

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INDICATOR: ANNUAL NUMBER OF R&D MISSILE TEST FIRINGS

DESCRIPTION OF INDICATOR

The indicator is a summation of the number of test firings conducted during a particular year for the purpose of research and development of each missile type associated with a category of weapon systems. It can be tabulated in terms of each missile type (e.g., SS-19s) or for the entire category (e.g., ICBMs) or for an entire force (ICBM, SLBM, cruise missiles).

SIGNIFICANCE OF INDICATOR

The annual number of test firings of a particular type of missile is a measure of the progress that particular missile is making toward operational deployment status. Radical changes in the indicator from year to year can provide a basis for inferences made about the status of a particular technology. The number of R&D test firings of a category can give a general impression of the scope and pace of force-wide missile development programs. The number of R&D test firings for an entire force loses much of its meaning due to the loss of detail in the individual force elements when lumped together.

LIMITATIONS OF INDICATOR

It is difficult to determine whether or not a particular test firing of a missile was conducted for basic R&D purposes or for reliability determination and operational training or all of these. In addition, little is known about the efficiency of Soviet test programs. They traditionally conduct more test firings than the U.S. on their ballistic missiles. Consequently, little can be gained from comparing U.S. and Soviet values of the indicator.

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The indicator is of value, however, in comparing the progress of a particular weapon system with that of other weapon systems previously introduced by that particular nation.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The number of missile test firings can be determined with high precision by national technical means. It is extremely difficult to conduct a flight test of a ballistic missile covertly. Flight tests of cruise missiles, however, can be conducted effectively in covert stages with little or no full system flight testing before deployment. The uncertainty associated with the number of these flight tests could be large.

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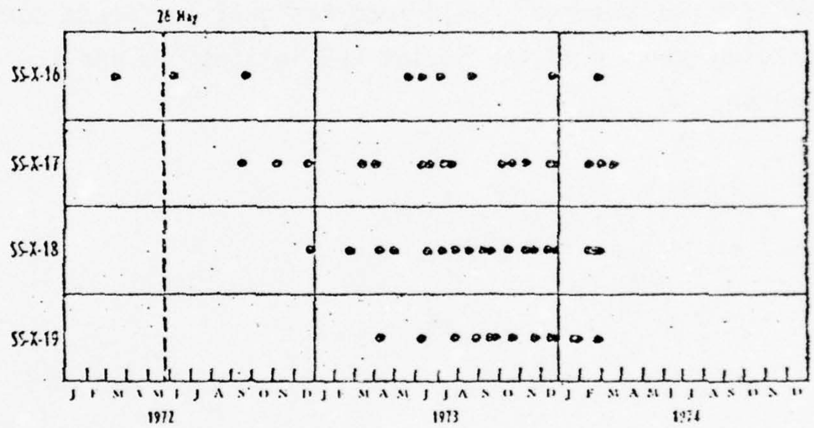
SAMPLE USE OF INDICATOR

[Supplied by Department of Defense]

SOVIET OFFENSIVE MISSILE R&D



[Classified version of slide is in committee files]

As you know and as this slide demonstrates, we have monitored very carefully the movement of the Soviet program. The red line at the left indicates the signing of the SALT I agreements. Subsequent to the signing of the agreement we see a Soviet research and development program of astonishing depth and breadth. This is not to say that they deceived us in the agreement or that the program had been designed to emerge after the agreement. Obviously, these developments were in the cards years in advance because the Soviets have the same kind of leadtime problems that we have. But I think it is fair to say that many people, particularly people in the arms control community, have been surprised by the strength of those programs.

Source Document: U.S.-U.S.S.R. Strategic Policies, James R. Schlesinger, SecDef, Testimony Before the Subcommittee on Arms Control, International Law and Organization of the Senate Foreign Relations Committee, 93rd Congress, 2nd Session, 4 March 1974.

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COMMENT ON THE USE OF THE INDICATOR

The author uses the indicator (in much more detail than is usual) to provide the public with information concerning the pace of Soviet ICBM developments since the signing of the strategic arms limitation agreements in 1972. He did not present the material in an alarmist fashion but forthrightly expressed astonishment and surprise at the depth and breadth of the Soviet R&D program. This expression could possibly have made more of an impact and would have been further supported if data had been displayed which reveals whether or not the pattern of ICBM tests for the systems shown is typical or atypical of previous generation ICBM development programs. Then an observer could form rational judgments concerning the underlying purpose of the Soviet R&D initiatives and the appropriate U.S. response.

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INDICATOR: ANNUAL RESEARCH AND DEVELOPMENT EXPENDITURES

DESCRIPTION OF INDICATOR

This indicator is the annual dollar or ruble outlay for military research and development. It includes expenditures for basic laboratory and theoretical research, system and subsystem development and testing, and test and evaluation of prototype and production units.

SIGNIFICANCE OF INDICATOR

The indicator is a gross measure of the magnitude or scope of a nation's military research, development, test, and evaluation. When one is certain that it includes expenditures for all RDT&E applied to military systems and goals, it is a good indicator of the emphasis a nation places on innovation and search for fundamental breakthroughs which could lead to a military advantage. This is true if the comparison is made year-to-year for the same nation.

LIMITATIONS OF INDICATOR

For a variety of reasons, this indicator is probably the least meaningful in comparing U.S. and Soviet RDT&E efforts. Determining the real costs of system acquisition and R&D is difficult enough in the U.S., even when researchers nominally have unhampered access to detailed data. It is several orders of magnitude more difficult to establish the costs of Soviet programs, even in rubles; and converting rubles into U.S. dollars invariably introduces new inconsistencies. In addition, the value of the indicator even if well known would not provide a measure of effectiveness of Soviet RDT&E because the efficiency of their R&D system is not known.

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Consequently, the best that one can hope for is a rough idea of the structure of Soviet spending on RDT&E. The most that one can learn is approximately how burdensome Soviet RDT&E expenditures on defense are to the Soviet economy.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

Since the bulk of defense-oriented Soviet R&D is directly supported from the central science budget, which contains civilian R&D funding as well, its magnitude can only be guessed. In addition, the Soviet expenditures for T&E is an unspecified part of the overall defense budget. Consequently, the uncertainty in an estimate of yearly Soviet RDT&E expenditure is large.

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SAMPLE USE OF INDICATOR

U.S. AND SOVIET DEFENSE EXPENDITURES, SELECTED YEARS, 1960-1974

UNITED STATES

Item	Billions of 1970 dollars				Percentage Distribution			
	1960	1965	1970	1974	1960	1965	1970	1974
RDT&E	8.27	9.59	8.78	7.32	13.5	15.5	10.8	11.5

USSR

Item	Billions of 1970 rubles				Percentage Distribution			
	1960	1965	1970	1974	1960	1965	1970	1974
RDT&E	2.33	3.26	4.55	5.76	13.2	16.9	19.7	22.7

Source Document: U.S./U.S.S.R. Net Technical Assessment: The R&D Balance, B. W. Augenstein et al., Rand, December 1974.

DISCUSSION

The author displayed estimates of U.S. and Soviet RDT&E expenditures in dollars and rubles and as a percentage of the total defense budget. For both countries, the R&D data include nuclear and military space outlays as well as ordinary defense outlays but exclude civilian space. The U.S. figures include those procurement fund allocations actually devoted to RDT&E and also the AEC's military R&D funding.

COMMENT ON THE USE OF THE INDICATOR

The author pointed out the caveats on the validity of using expenditures as a means of measuring the effectiveness of the Soviet RDT&E effort and goes on to say that in spite of them, comparisons of U.S./Soviet RDT&E expenditures are inevitable. He does, however, confine the comparison to the absolute

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and percentage increases over time individually for the U.S. and Soviet Union. Such comparisons reveal the nature of RDT&E programs for each side. For the Soviet Union, the data reveal a stable funding of R&D institutions with continuous growth albeit at a diminishing growth rate each year. This reflects the Soviet philosophy of supporting a stable research and development effort which is separated organizationally and functionally from production. For the U.S. the data reveal the counterpart U.S. RDT&E effort fluctuating subject to the vagaries of system production and to the system-focussed decisions on which it hinges. Such comparisons are useful and point out unique features of the different attitudes taken by the U.S and Soviet Union in supporting military RDT&E.

It is worth noting that the authors stop short of comparing U.S. and Soviet expenditures. They correctly point out that such comparisons are of little value since estimates of ruble/dollar exchange ratios can vary widely (2.75 to 4.5 from different sources).

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INDICATOR: NEW SYSTEM INITIAL OPERATIONAL CAPABILITY (IOC)

DESCRIPTION OF INDICATOR

The date on which the first unit of a new weapon system is deployed in the operational force is the IOC date for that system. If several new systems of a given class, e.g., ICBMs, have IOCs within a certain time span, the data can be displayed as the number of new systems introduced during that period. Depending upon the intended use, the data can be expanded to include systems over any component of or over the entire strategic force.

SIGNIFICANCE OF INDICATOR

The indicator is a direct measure of the pace at which a nation is modernizing its strategic forces or a component of them. It is an indirect measure of the efficiency of the RDT&E effort supported by a nation.

LIMITATIONS OF INDICATOR

The indicator can be misleading if the design/procurement philosophies of the two sides differ radically. For instance if one side designs some of its forces for multiple missions and the other designs and procures a different vehicle for each mission, the latter will show a higher number of new systems introduced over a generation of system life. It can also be misleading if one side prefers to modify existing systems to upgrade its capability as opposed to modernizing the force with a completely new system.

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ESTIMATE IN THE UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

Since new systems are deployed toward the end of a rather extensive and visible testing phase, the uncertainty in a measured value of this indicator is very small. A contributing factor to this is the complete insensitivity of the measure (in its general usage) to a few months' error in the actual IOC.

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SAMPLE USE OF INDICATOR

NUMBERS OF NEW STRATEGIC OFFENSIVE SYSTEMS,
U.S. AND U.S.S.R., 1960-1974

	U.S.	U.S.S.R.
Strategic missiles	11	14
Strategic and tactical aircraft	11	14
Air-to-surface missiles	7	6
Surface-to-air missiles	8	9

Source Document: U.S./U.S.S.R. Net Technical Assessment: The R&D Balance, B. W. Augenstein, et al., Rand, December 1974.

DISCUSSION

The authors display the numbers of major new weapon systems which were deployed between 1960 and 1974. They comment on the inability of the Soviets to deploy an appreciably larger number of new systems than the U.S. over the period in question considering the continual increase in annual Soviet RDT&E expenditures for the same period. They attribute this to a better RDT&E productivity for the U.S.

COMMENT ON THE USE OF THE INDICATOR

The indicator simply and vividly displays the relative pace of modernization of comparable U.S. and Soviet systems. There is, however, a possibility of being mislead by the choice of time period. If the data were expanded to include the time through 1976 (impossible for this particular study), the four new Soviet ICBMs would be included, giving the Soviets a

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substantial 15 to 11 advantage in this force element. If the time period were changed to 1970-1976, the data would show the Soviets ahead four to zero in the same measure. The sensitivity of result to choice of time period is a shortcoming of this indicator. For time periods reasonably chosen, however, it is a useful tool for comparison.

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INDICATOR: PROCUREMENT QUANTITY OF ICBMs, SLBMs, AND STRATEGIC BOMBERS

DESCRIPTION OF INDICATOR

This indicator is the number of ICBMs, SLBMs, and/or strategic bombers procured during a specified period of time. It is nearly synonymous with the number of such systems constructed or deployed, differing only in the time at which the systems begin to count.

SIGNIFICANCE OF INDICATOR

This indicator is a good measure of the pace at which a nation is conducting the modernization of a particular strategic force element or the entire strategic force (depending upon the categories of systems included). Along with the number of systems with IOC in a given period, it is a measure of the pace and breadth of such modernization. Given the economic cost of procuring such systems, a rapid pace of modernization of a force element or the entire force can be an indication of the intentions of a nation in maintaining or altering the strategic balance.

LIMITATIONS OF INDICATOR

The indicator can be misleading when not used in conjunction with historical precedents for procuring or deploying new weapon systems. The differences in institutional and budgetary practices of the U.S. and Soviet Union can lead to quite different procurement and deployment patterns unrelated to a national strategic posture or a change in that posture. The choice of time period over which the data is displayed must be carefully chosen in order that distortions are not introduced. Systems are seldom procured or deployed at constant yearly rates so maximum rates can fluctuate

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significantly from average rates. Care must be exercised to capture the entire procurement/deployment history in the life cycle of a particular system. In addition, ICBMs and SLBMs are procured in amounts larger than the number deployed so that normal maintenance, training, and testing requirements can be met. These quantities are different for each side. This results in some distortion in the indicator as a measure of the strategic balance.

UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The procurement quantities of Soviet ICBMs and SLBMs are not known with precision. The number of launchers for such missiles are more precisely determinable. Over time, however, the number of such missiles actually deployed is determinable with lower uncertainty than the procurement quantity. The latter observation also applies to strategic bombers.

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INDICATOR: PROCUREMENT QUANTITY OF INTERCEPTORS AND SAMs

DESCRIPTION OF INDICATOR

This indicator is the number of interceptor aircraft and surface-to-air missiles procured during a specified period of time. It is nearly synonymous with the number of such systems constructed or deployed, differing only in the time at which the systems begin to count.

SIGNIFICANCE OF INDICATOR

This indicator is a good measure of the pace at which a nation is conducting the modernization of its air defenses. Depending upon the magnitude of the deployment of systems being replaced, it is a measure of the emphasis or change in emphasis placed upon the importance of air defense in a nation's strategic posture.

LIMITATIONS OF INDICATOR

The indicator can be misleading when not placed in the context of the extent of the deployed quantities being replaced. Distortions can result from a poor choice of the time period over which the data is displayed.

ESTIMATE OF UNCERTAINTY IN A MEASURED VALUE OF THE INDICATOR

The estimated number of Soviet interceptors and SAMs, especially SAMs, procured is highly uncertain due to the possibility that these systems can be covertly stored in warehouses, sheds, and other nondescript storage facilities. The number of such systems deployed is subject to less uncertainty due to their size and likely deployment patterns.

ASSESSING THE STRATEGIC BALANCE

BY

GERALD T. RUDOLPH

JUNE 1976

SUBMITTED TO THE

INTERNATIONAL INSTITUTE FOR STRATEGIC STUDIES

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S U M M A R Y

'ASSESSING THE STRATEGIC BALANCE'

BY

GERALD T. RUDOLPH

This paper examines the static and dynamic balance of Strategic Nuclear forces of the US/USSR over the decade of the 1970s. Six measures of static force potential are arrayed, compared, and discussed. On the basis of these important measures, it is concluded that the Soviet Union will have reversed the strategic balance over the '70s from a position of inferiority to one of perceptible or comfortable superiority in all vital war fighting static indicators. It is argued that by the early '80s, the Soviets may well be perceived by most interested nations as the superior nuclear power.

The Dynamic Balance is examined by selecting those warfare categories which are not now or will not be mutually deterred as the Soviet forces continue to build; and, force exchange calculation results are used to discuss the real military significance of the Soviet strategic force buildup. From this examination, it is concluded that the US may no longer be able to deter certain counterforce attacks unless it makes substantial changes in its force posture or unless SALT can lower force levels to preclude this unstable, future condition.

Strategy, deterrence, and US force posture implications are discussed with the conclusion that Soviet strategic forces, by the early 1980 era, will pose a serious military threat to the US for which there may be no credible deterrent.

B I O G R A P H Y

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The data and views expressed in this paper are the author's and do not represent the official position of the US Air Force, the US Department of Defense, or the US Government.

ASSESSING THE STRATEGIC BALANCE

A major U.S. national security concern today is the momentum of the Soviet strategic nuclear buildup. The dominant belief in Washington appears to be that this buildup poses no danger to the U.S. nuclear deterrent posture. The fear is that the buildup could have serious international consequences for the U.S. and its allies if perceptions of Soviet superiority should result. Consequently, much attention has focused on how perceptions of the Strategic Nuclear Balance are formed, what measures of the balance are relevant, and how much imbalance the U.S. can accept. A U.S. policy of "essential equivalence" has been adopted which accepts imbalance in some measures but calls for aggregate equality between the superpowers.

Unfortunately, there is a wide difference of opinion in the U.S. Government on the importance of strategic balance measures; hence, what constitutes equality. There are also differences on what forces are sufficient for deterrence and how one assesses deterrent capacity. These differences have had many important results. For example, a strong Defense Department argument for throw weight limitations at SALT II was rejected by the Administration. This led to the Vladivostok accords limiting only delivery vehicles. Administration nuclear policy initiatives are under challenge by the American media and the Congress. New strategic force programs, proposed as necessary to maintain "sufficiency," are under attack by pressure groups and even some 'Defense Oriented' Congressmen.

Partly because of these differences of opinion over how to react to the Soviet buildup, the level of American public understanding of the strategic balance is low. There does seem to be an awareness the Soviets have reached "nuclear parity" with the U.S., but the combination of differing official pronouncements, the atmospherics of detente, and the promise of SALT seem to have had a major impact on public support for increased strategic spending. Few US Government officials have warned the public of serious pending force imbalances and have survived the consequences. Such rhetoric is viewed as being inconsistent with building the proper atmosphere in which to pursue the detente policy, by whatever name.

The time would appear right for institutions which can affect public opinion in the West to conduct a more penetrating review of the substantive issues of the Strategic Balance, Deterrence, and of public and governmental perceptions of this controversy.

This paper presents a view representative of an increasing faction in the American Military Establishment, that the Soviet buildup not only will provide them a clear, perceptible margin of superiority from a political impact perspective; but also, will pose real dangers for the U.S. deterrent posture. By the end of this decade, unless SALT succeeds in lowering overall force levels, or unless U.S. unilateral actions are taken to improve the counterforce effectiveness of its strategic forces, the Soviets will achieve force capabilities tantamount to Strategic Superiority. For the first time, certain counterforce options will be open to the Soviets for which the U.S. may have no credible deterrent. Like it or not, the era of counterforce is approaching. The level of public awareness of this matter must be raised. Implicit in this American Military view is the belief that with strong public support for increased U.S. strategic force expenditures, detente will be enhanced, not harmed. A strong US commitment to strategic sufficiency will bring about a Soviet willingness to substantially reduce mutual force levels to enhance stability.

This is an assessment of both the static strategic balance and the real or dynamic balance relating the capability of each side to execute or to deter attacks across the spectrum of nuclear war.

I. THE PERCEIVED BALANCE: STATIC MEASURES

No one yet knows how our own or other governments come to form their beliefs about the superpower strategic balance. With fewer facts, analysis resources, and direct interest, other governments are bound to have less insight into the true balance than the superpowers. About the best an interested nation can do in assessing the balance is to examine force inventories and weapon capability data available from open source, alliance, or intelligence sources. Complex computer simulations of superpower force exchanges are out of the question for all but the most advanced and concerned countries. However developed, these perceptions translate into political power for the superpowers.

It is not the purpose here to develop this generally accepted coupling between military power and political and economic power. It is interesting to note, however, that some high officials in the U.S. Government have publically expressed doubt on the role of strategic nuclear forces in the political power equation. This expressed view points to the impotence of the superpowers to affect events among nations over which both have overwhelming superiority. This, it is argued, demonstrates the uselessness of strategic forces. Of course, the contrary view

is that what is being evidenced is the balancing effect between the superpowers and the importance of preventing an imbalance, in particular, a U.S. inferiority. The case for the relationship between strategic weapons and political power would be more obvious were there only one nuclear superpower.

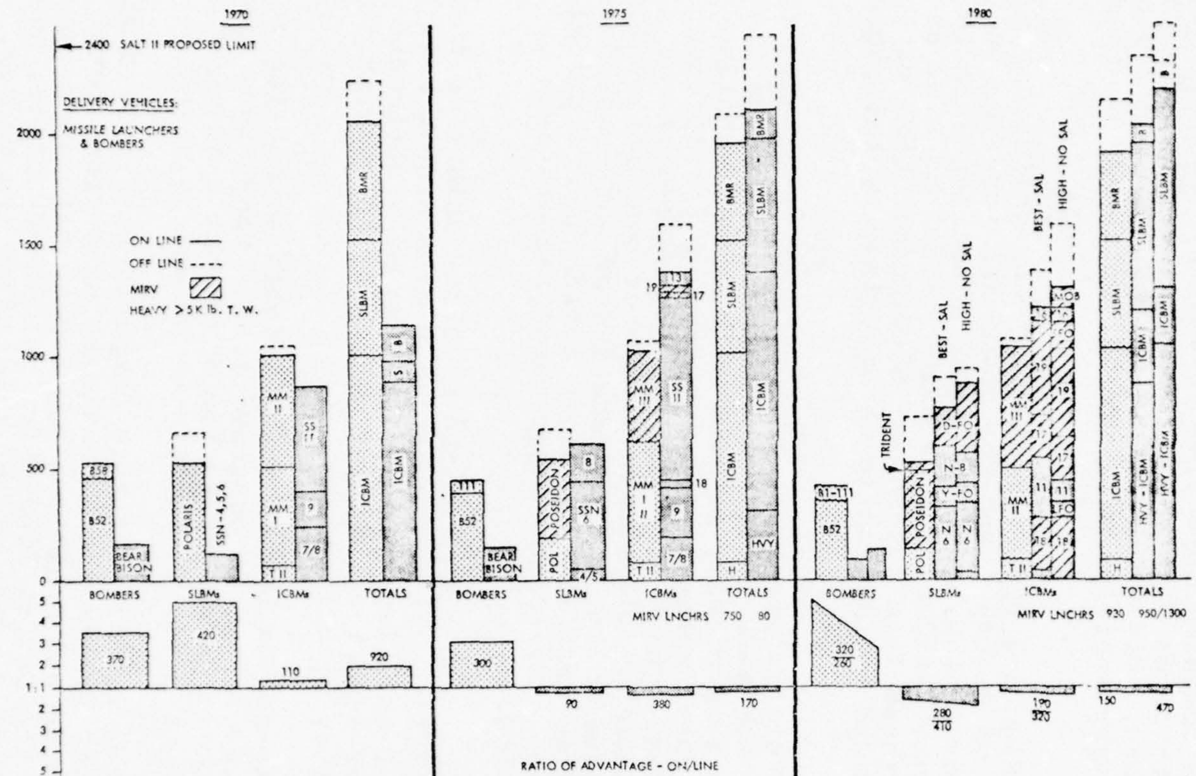
What follows are displays of six of the most common static indicators of strategic forces taken from data generally accessible to all nations. Values are shown by force component: bombers, SLBMs and ICBMs; and by aggregate force capability. The changing balance is indicated by looking at the 1970 decade at the beginning, mid-point, and close of the decade. The projected forces for the end of the decade are those currently planned by the U.S. including the B-1 bomber and TRIDENT submarine programs. The Soviet projection assumes compliance with the SAL I interim agreement and, subsequently, with a SAL II agreement along the lines of the Vladivostok terms. That is, the Soviets are assumed to continue the deployment of their latest generation weapons at about the current rate. At the end of the decade, both US and Soviet projections fall below the proposed treaty limits of 2400 total and 1320 MIRVed delivery vehicles. An additional Soviet projection is shown to the right of this 1980 best estimate which represents a maximum Soviet deployment program if they chose to do so and if no SAL II agreement is reached. A ratio of advantage is displayed below each comparison. All values represent the author's best estimates. Uncertainty in present and future capabilities has been examined but is not presented here.

<u>Delivery Vehicles.</u> Figure 1 displays operational delivery vehicles: bombers and missile launchers not undergoing modification. Only mutually agreed strategic systems are included. The new Soviet BACKFIRE bomber is excluded because not all agree on its strategic role and the Soviets oppose its inclusion. Forward based and tactical nuclear weapons are excluded in most "central system" strategic balance assessments.

The effect of SAL I in halting new Soviet silo construction can be seen by the leveling off of delivery vehicles. SAL II limits will be reached near the end of the decade. (SAL II limits total deployed delivery vehicles not just operational ones, shown here). A reduction in Soviet operational ICBMs is due to the retrofit program taking current silos off-line to install new generation ICBMs or to harden silos. The Soviet ICBM lead is offset somewhat by the U.S. bomber advantage, ignoring BACKFIRE and Soviet medium bombers.

Figure 1

STATIC BALANCE '76
DELIVERY VEHICLES



NOTE:

1. RATIO OF ADVANTAGE IS INDICATED BY THE HEIGHT OF THE GRAPH. ABSOLUTE DIFFERENCE (ROUNDED OFF) IS SHOWN BY THE NUMBER IN THE RATIO GRAPH.
2. SYMBOLS USED ARE:

HVY	- HEAVY ICBMs	C3, C4	- TRIDENT SLBMs
SFO	- SMALL FOLLOW-ON	Y, D	- YANKEE, DELTA SSBNs
LFO	- LARGE FOLLOW-ON	N	- SSN 4, 5, 6, 7, 8 SLBM
MOB	- MOBILE MISSILE	17, 18, ETC.	- SS17, 18, . . . ICBMs
H.D.	- HOUND DOG ASM	MM	- MINUTEMAN
T II	- TITAN II ICBM	(hatched box)	- MIRVED SYSTEMS

3. A LAUNCHER IS AN SLBM TUBE, AN ICBM SILO, OR EQUIVALENT SOFT MISSILE LAUNCHER. THIS WOULD NOT REFLECT AVAILABLE MISSILES IF LAUNCHERS ARE CAPABLE OF BEING RELOADED AFTER FIRING.

Over the decade, the Soviets will have doubled their delivery vehicles compared to a U.S. reduction. In the aggregate, there exists rough parity for this measure now, with a slight Soviet lead. Given SAL II limits and compliance with the treaty, delivery vehicles will remain "balanced" by these definitions.

Warheads. Figure 2 displays the warheads on the operational missiles of Figure 1 and the bombs and missiles on operational bombers. U.S. past and present dominance in this measure is evident. Earlier U.S. MIRVing gives the U.S. an ICBM and SLBM warhead lead but Soviet MIRVing of ICBMs captures the ICBM warhead and total missile warhead lead by the end of the decade.

As with all static measures, caution must be used in the interpretation. Warheads reflect the number of targets that can be attacked. To more closely reflect this target handling capability, a warhead measure ought to account for defense penetration losses. The U.S. advantage at the end of the decade portrayed here would vanish if bomber penetration losses through the massive Soviet air defense system were considered. The static measures used in this paper avoid the additional complexities imposed by scenario dependent factors such as defense penetration.

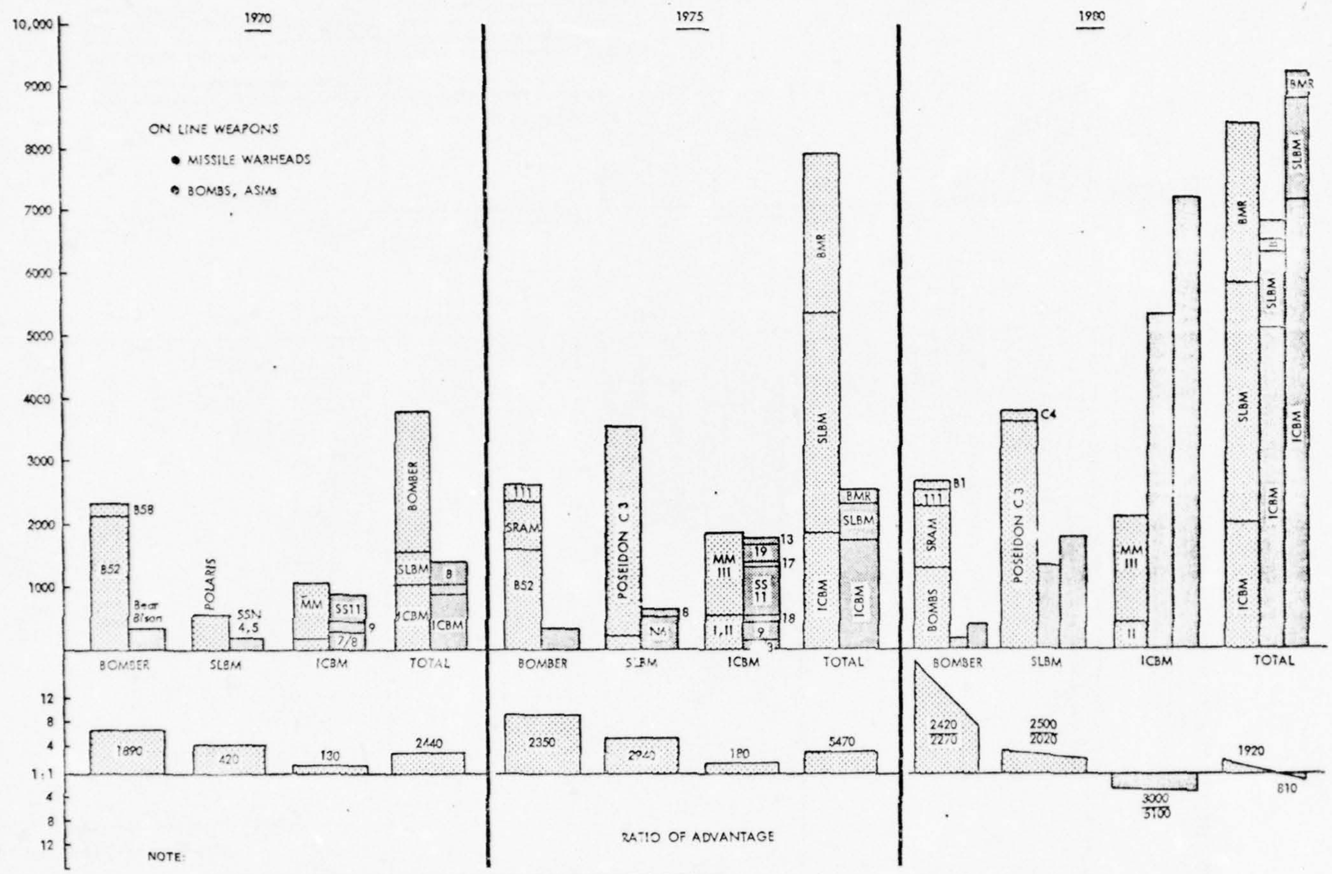
Throw Weight. The significance of throw weight is that it shows the potential for future capability of a side's existing forces. That is, existing throw weight can be fractionated to provide a greater number of smaller warheads, increasing the war fighting capability of a force.

The significance of bomber throw weight, accounting for over half the U.S. total, is controversial. Many argue that bomber payload or throw weight is too different a measure to be compared with or added to missile throw weight.

Accepting the validity of this comparison, Figure 3 shows that only the U.S. bomber force provides the current total U.S. throw weight margin and minimizes the Soviet margin at the close of the decade. The Soviet ICBM throw weight advantage, however, is large now and approaches 4:1 by the end of the decade. Some estimates place this ratio as high as 7:1 at the completion of the current missile deployment program in the early '80s.

Figure 2

OPERATIONAL WEAPONS



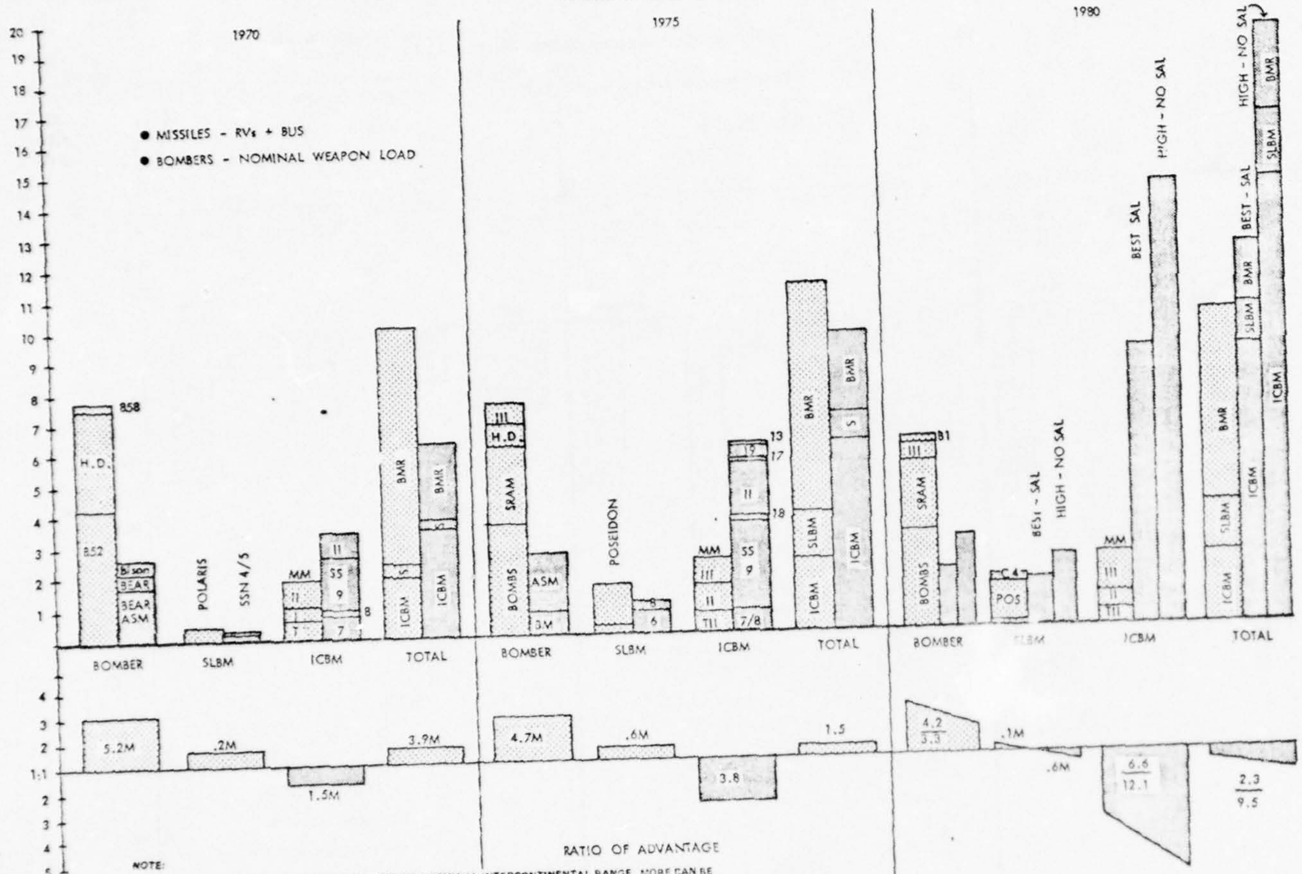
NOTE:

1. BOMBER PAYLOADS ARE FOR NOMINAL LOADINGS FOR AVERAGE MISSIONS (RANGE AND ALTITUDE PROFILE), NOT MAXIMUMS.

2. BOMBER AIR-TO-SURFACE MISSILES ARE INCLUDED HERE EVEN THOUGH PLANNED FOR DEFENSE PENETRATION IN MOST CASES.

Figure 3

THROW WEIGHT (mlbs)



NOTE:

1. MISSILE THROW WEIGHTS ARE DEFINED AT A NOMINAL INTERCONTINENTAL RANGE. MORE CAN BE "THROWN" TO SHORTER RANGE; LESS TO LONGER RANGE.

2. BOMBER "THROW WEIGHT" CAN BE VARIOUSLY CALCULATED. HERE, TOTAL BOMB AND MISSILE PAYLOAD WEIGHTS ARE USED CONSISTENT WITH THE NOMINAL NUMBERS OF WEAPONS OF FIGURE 2. THIS UNDERESTIMATES MAXIMUM (RANGE - PAYLOAD) CAPACITY BUT OVERESTIMATES CAPACITY, IN THE VIEW OF MANY, BY COUNTING NON-WARHEAD FACTORS SUCH AS FUEL AND ENGINE WEIGHT OF AIR-TO-SURFACE MISSILES (ASMs).

Yield. Raw yield of operational warheads (shown only in Figure 6) is not a meaningful measure of weapon effectiveness, but, Soviet dominance here may influence perceptions. The huge weapons carried by the Soviet heavy missiles account for most of this lead now; but, as their MIRV program progresses, raw yield is reduced. This is due both to smaller MIRV warheads and to the use of throw weight by the MIRV delivery system or "bus."

EMT. The first of the important measures of war fighting performance is shown in Figure 4. Equivalent or Effective Megatons (EMT) reflects the damage potential of a side's weapons against soft point or area targets. Because the distance from ground-zero to a point vulnerable to a specified level of overpressure is proportional to the cube-root of yield, and because the area affected is proportional to distance squared, a two-thirds power of raw yield is used to better describe the effect of yield on the ground. Stated another way, equivalent megaton units can be converted to units of damageable area by multiplying EMT by a constant for each overpressure value of interest.

Again, the importance of the U.S. bomber force is evident in balancing the current and projected Soviet lead in this measure. The rise of Soviet EMT as they MIRV, in spite of a raw yield decline, reflects the fact that more area can be damaged with smaller but more numerous weapons than with a few larger ones. In the aggregate, the current Soviet edge in soft target potential grows to nearly a 2:1 margin if bomber penetration is accounted for.

CMP. A more complex static measure which combines weapon delivery accuracy and yield into a single measure of hard target damage potential is shown in Figure 5. Because delivery accuracy is stated in probabalistic terms, usually Circular Error Probable (CEP), a weapon's ability to destroy a hard target is mathmatically formulated as a Probability of Kill (Pk). If the weapon dependent terms in this Pk equation are grouped together, a new parameter is formed, herein called Counter Military Potential (CMP). These weapon dependent terms are: the number of weapons per target, the yield per weapon, and the CEP per weapon. CMP can be thought of as the probability of applying a given over-pressure to a target. The other term of the Pk equation, target hardness, represents the resistance to all nuclear weapon effects but is usually discussed in units of overpressure. The CMP of a total force is simply the sum of individual weapon CMPs, just as throw weight or yield are added.

Figure 4

EFFECTIVE YIELD (EMT)

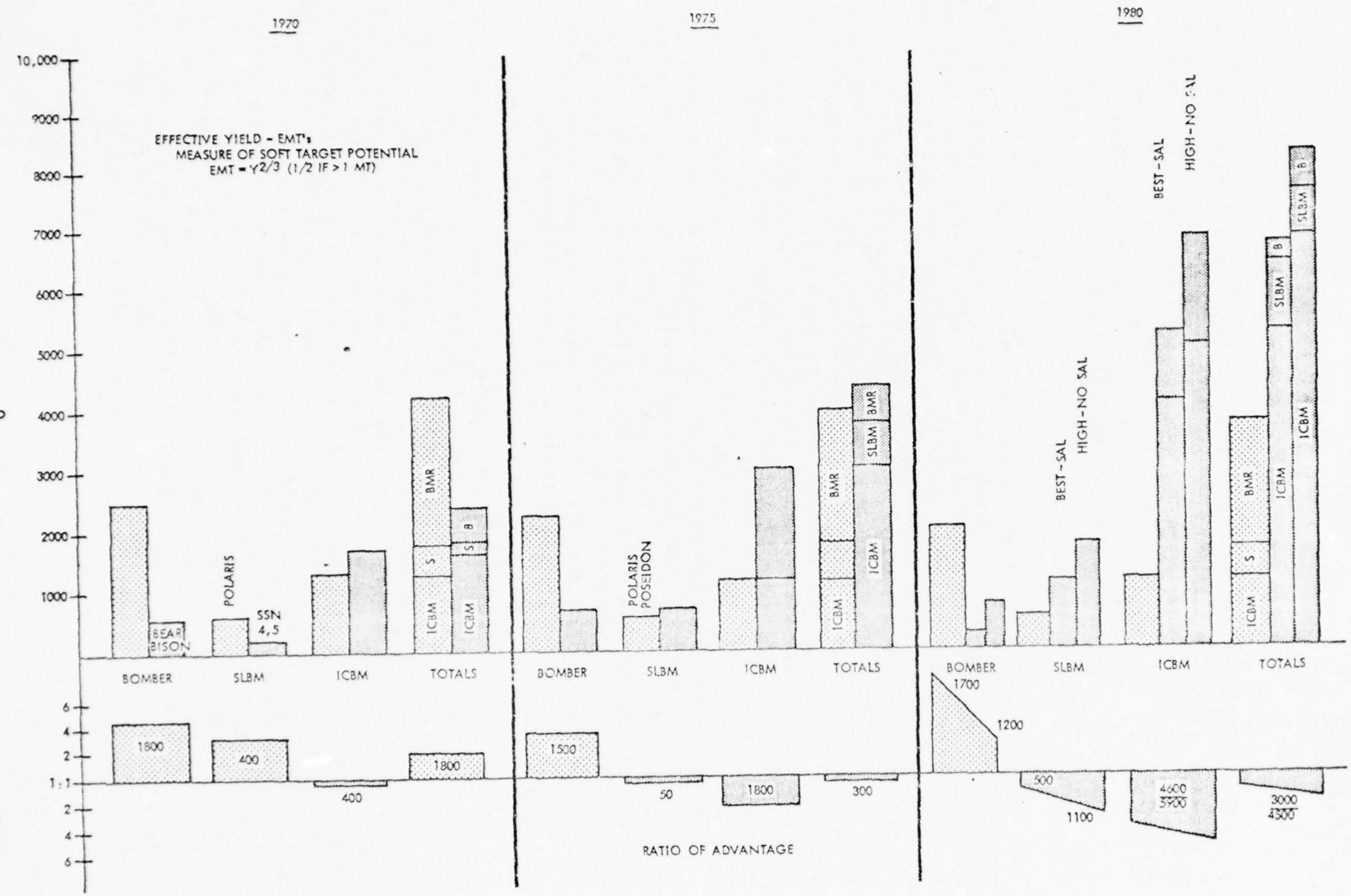


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Figure 5

HARD TARGET POTENTIAL (CMP)

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The CMP measure provides some insight into a media and debating issue: The belief of many that the U.S. lead in warheads and delivery accuracy is more than adequate compensation for the Soviet lead in throw weight and yield. Some believe that this idea was central to the SAL I interim agreement.

The chart (Figure 5) shows approximate parity in past and present missile CMP with the U.S. bomber force providing the real dominance. Independent of the bomber survival and penetration issue, many feel this interpretation is misleading because the vital hard targets, missile silos, may be empty by the time bombers arrive. But again, scenario dependent factors are not accounted for in these static measures. Note the dramatic rise of Soviet CMP as their MIRV program progresses. They capture the lead in hard target potential, the second vital war fighting measure, in spite of U.S. accuracy technology because of their greater number of higher yield multiple warheads. Only the US bomber force provides some balance. (The damage probability values shown will be discussed later.)

A caution: values of CMP are extremely sensitive to accuracy assessments which, themselves, are fairly uncertain. Some published articles, based on a similar analysis conclude the opposite: US superiority. This conclusion can be reached by taking extremes of the CEP uncertainty range; that is, upper bounds for US accuracy (best CEP) and lower bounds for Soviet accuracy (worst CEP). The displayed CMP values are based on nominal or central value CEP and yield estimates. The US must necessarily keep its true understanding of hard target capability classified to protect both its own accuracy capability and its estimates of Soviet accuracy.

Other Static Measures. There exist hundreds of other force parameters and capabilities which could be compared when examining the Strategic Balance. Most of these describe more complex technical or force interactions which are not the domain of the layman. To list a few of the more important: bomber penetration capability to include low altitude ability, terrain following radar, electronic warfare sophistication, penetration weapons, and radar cross section could be compared; Air Defense capability listing numbers of radars, surface-to-air missiles, and interceptor aircraft, could be readily compared; Missile Defense including ABM radars, interceptor missiles, penetration-aid handling and exotic techniques such as laser-ABM systems could be listed; Anti-submarine warfare capability could be compared in a way that includes the dominant factors of area search, depth, active and passive detection capability, submarine quietness, and kill weapons such as homing torpedos. There also exist important

general measures such as weapon reliability, alert rates, vulnerability to electronic warfare and nuclear effects. As strategic arsenals become more sophisitcated, warning, attack assessment, command and control, and so called dynamic battle management capabilities are becoming more important measures of total force capability. Strategic warning, provided by intelligence systems, can provide the time necessary to increase alert or at-sea rates. Tactical warning provides the time to launch ground alert forces and to make the war fighting command capability more survivable. Attack assessment can provide the capability to select an appropriate response either before or after the first strike impacts depending on the degree of sensing and data handling capability. Dynamic battle management includes those capabilities important for flexible response options and limited nuclear wars, such as: pre-impact missile retargeting; launch-under-attack for ICBMs; empty-silo information on enemy missiles to avoid wasting weapons; bomb damage assessment for one's own weapons to know if second attack waves are required; attack damage assessment on one's own forces to know what retaliatory capability still exists. Invulnerable or hardened command, control and communication assets such as airborne or underground command posts, satellite relays, high data rate communication and computer systems could easily spell the difference in a nuclear engagement.

Most of these factors are best treated in a dynamic balance context where interactions such as bombers vs air defense can be quantified depending on the scenario being considered. Most of these factors are included in the dynamic exchange results of this paper.

Aggregate Perception. While there are many other factors which need to go into an assessment of the strategic balance, these other factors are difficult to quantify and probably contribute only generally to perceptions of the balance. The limited, but important static measures shown here capture the essence of the changing force balance. Figure 6 summarizes these measures and adds a 1985 Soviet Best Estimate (SAL II Consistent) for the purpose of putting the 1980 High Estimate in perspective. It can be seen that rough parity in strategic delivery vehicles exists now and will continue balanced with a Vladivostok accord. Exclusion of BACKFIRE and Soviet cruise missiles in such an accord will improve the Soviet margin in delivery vehicles. Throw weight, the potential for creating more war fighting capability, might be variably perceived dependent on one's view of bomber importance. The Soviet ICBM throw weight advantage is impressive and growing. This war fighting potential is, in fact, being realized as can be seen by the rise in Soviet warheads, EMT, and CMP. These latter measures are the best simple measures of military capability. These all move to a Soviet advantage if bomber penetration losses are accounted for.

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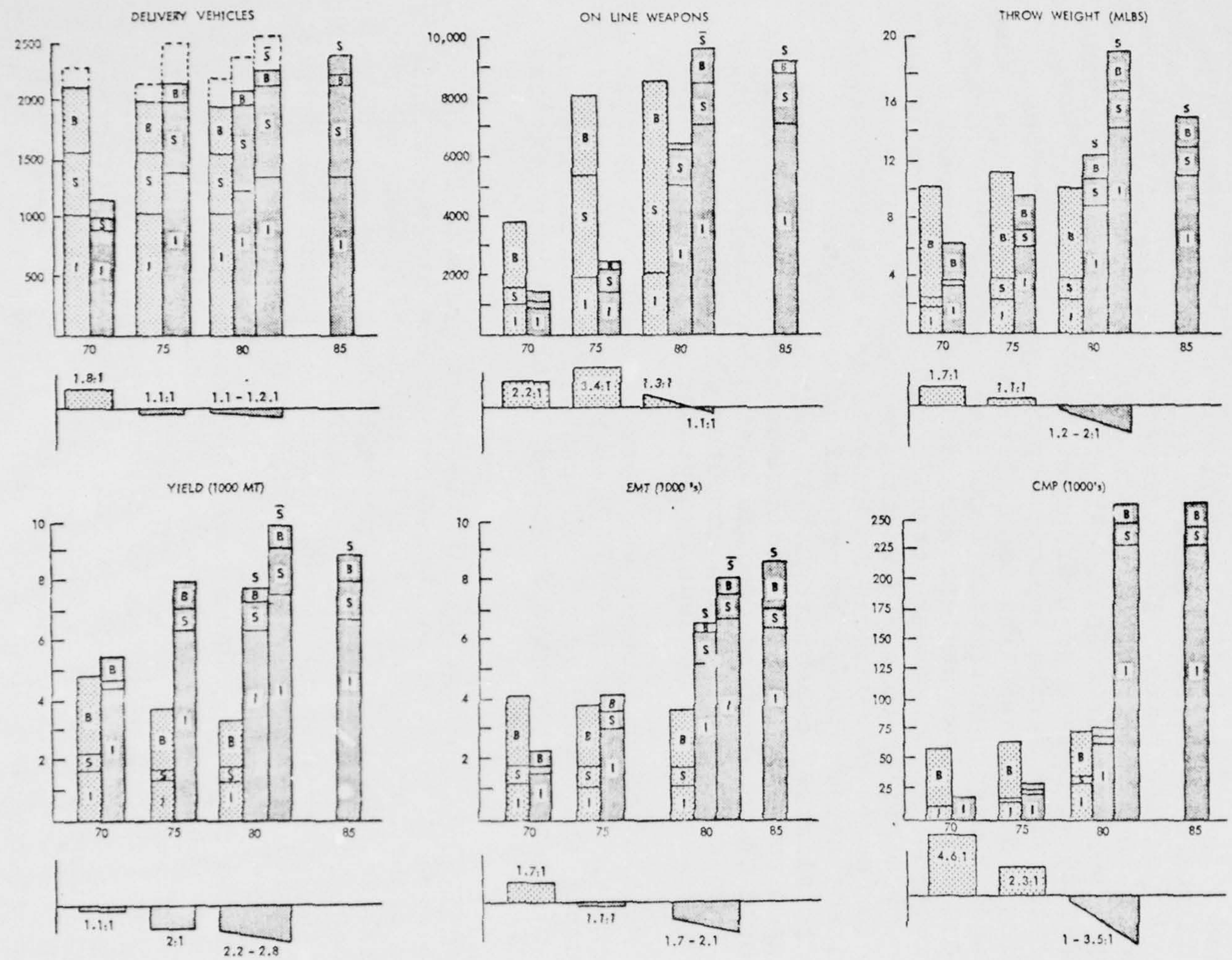
Figure 6

STATIC MEASURES SUMMARY



Over the decade, the Soviets will have moved from a position of inferiority to a position of at least a perceptible superiority, if not a comfortable margin, in all measures. The single exception, operational warheads, temporarily remains a US advantage until the Soviets complete their ICBM MIRV program. This measure, too, goes to the Soviets if only half the US bomber force were perceived as being capable of surviving an attack or of penetrating Soviet air defenses. Soviet SLBM MIRVing will further increase their lead in this measure in the early 1980s.

A concern over perceptions of Soviet strategic superiority appears to be well founded, based on these measures. The only question is when--not whether. The interpretation favored in this analysis is that unless the US acts to improve its capabilities by the early 1980's, the Soviet Union may well be perceived by most nations as the superior strategic power.

II. STRATEGY, DETERRENCE AND NUCLEAR ENGAGEMENTS

The true military significance of the rapidly increasing Soviet strategic capability cannot be assessed in the realm of simple static measures. For this, the possible outcomes of likely engagements must be calculated to establish which side could achieve a decisive advantage, or more important, to assess the impact on deterrence.

Deterrence. Because US national policy declares deterrence as the prime objective of strategic forces, the deterrent value of US forces should be, and is, the yard stick by which the US military measure the real strategic balance. The military is not overly concerned with static indicator comparisons. Nevertheless, serious differences exist over what constitutes sufficient deterrence.

The premise of deterrence is that a rational opponent will not attack if the risks of retaliation outweigh the gains of the attack. In its most obvious application, this concept says that a first striker will be deterred from attacking an opponent's population or urban-industrial centers if he thinks the opponent has the capability and the will to retaliate on his population. Most agree that this 'response-in-kind' capability is a credible deterrent to massive city attacks. However, for less than all out city attacks, such as a large but limited casualty attack on military forces, does the same threat of a response on the first striker's cities still deter? The Minimum Assured Destruction school (unaffectionately referred to as "MAD"ers), still prominent in US intellectual circles, argues "yes." Their premise is that if we make it clear we will destroy an opponent's population

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and economic base in response to any and all nuclear attacks on the US, then a resort to nuclear weapons would be unthinkable. Further, they argue that the fewer response options the US has, the more believable the city response would be to an opponent. The MADer's ideal US force structure would be only a few hundred survivable warheads matched to the opponent's city-population structure. In short, the higher the nuclear threshhold, the less likely the war.

At one time, this may have been a reasonable hypothesis relative to the USSR and it may yet be, relative to the PRC. The crux of the issue now is whether anyone, in particular the Soviets, can believe that a US President would execute a city response to a lesser level first strike, knowing the USSR has the capability to respond-in-kind on US cities. Such a response would be tantamount to committing national suicide. As such, it can not be credible. How is it the MAD school believes that the threat of a US retaliation on Soviet cities will deter an attack on US cities and yet not admit to the inverse? That is, the threat of a Soviet retaliation on US cities will deter the US from attacking Soviet cities, should an engagement begin at a lower level. Obviously, the MAD school risks all on the premise that an urban response will prevent all forms of nuclear wars from beginning and therefore no provisions need be made for other options if that deterrence should fail.

Flexible Response. The military and recent US administrations have recognized this problem and have tried to provide for more "flexible response" options. The deterrent concept has remained the same; namely, to insure that a US response capability confronts an opponent with the risk of losses which outweigh the potential gains across the entire spectrum of possible attacks and to insure that these response options are credible. The application of this principle is not without difficulties, however. Assessing an opponent's value system to arrive at a definition of unacceptable losses at lower levels of nuclear engagements is far less straightforward than in an urban-industrial context. Beyond this problem, the flexible response concept poses a difficult dilemma.

The deterrent power of a response option depends on its capacity to inflict unacceptable losses on the opponent. The credibility of a response option depends on its ability to minimize risks of higher order losses on one's self in subsequent rounds. A credible deterrent option must do both. The dilemma referred to is that the deterrent power of a response is enhanced by escalating to a higher level response than the initial attack. This is consistent with the MAD school view. But the credibility of a response is enhanced in the opposite direction. A lower level response bears no inherent escalatory risks. Finding a credible deterrent response option for each possible attack across the spectrum of engagements depends on one's ability to balance these two factors.

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A response which inflicts casualties of the same order of magnitude as the first strike, and which attacks the same character of targets as the first strike, is hereafter called a response-in-kind. To be effective, this response-in-kind must inflict unacceptable damage to achieve its desired deterrent power. To be credible, it must not change the character of the engagement or the level of collateral damage (i.e., escalate) unless there is no risk in so escalating. Escalation can be credible if force assymetries exist such that the opponent cannot counter-escalate.

To demonstrate how this concept of deterrence directly relates to the significance of the Soviet buildup, Figure 7 arrays a spectrum of likely engagements in order of escalation. A fundamental assumption here is that both superpowers value population and their economic base as paramount. Thus, escalation is measured in terms of so-called collateral damage: casualties and economic-industrial damage. A wide spectrum of scenarios are contained in each attack category suggesting a continuum of escalation. For simplicity and conceptual purposes here, distinct threshholds between attack cat.gories are used to convey the idea that the character of the conflict changes when a threshhold is crossed.

Urban Industrial Attacks. At the top of the spectrum are the various forms of city related engagements. It is of little consequence whether the intent of such attacks or responses is to destroy people, industry, or military targets. Nor is the number of weapons used of significance, above the few hundred required to attack each side's major urban areas. For all variants of this class, it is believed that hundreds of millions of people and enormous amounts of capital plant are destroyed, superior Soviet Civil Defense, notwithstanding. US "assured destruction" deterrent strategy focused directly on cities for the sake of destroying population and industry. Views differed as to how many weapons were needed and how many of an opponent's cities needed to be threatened for this strategy to be an effective deterrent, but fifty to five hundred weapons was the right order of magnitude. Recent policy changes seem to be moving the US deterrent concept more in line with what is believed to be the Soviet response doctrine for this class of war. That is, cities and population per se as the retaliatory objective will be replaced by selected military, economic, and political targets. The objective of this new targeting strategy is to inhibit the post war recovery capability of the opponent. The number of targets and weapons may increase several fold with this strategy and some major urban areas may be avoided if there are no valuable targets. But even though the targeting objective changes, cities are still heavily involved and the character of the war remains the same.

Figure 7

SPECTRUM OF ATTACKS

ATTACK CATEGORY	TARGETS (PER SIDE) TYPICAL OBJECTIVE	REPRESENTATIVE NUMBER	WEAPON REQUIRED	CASUALTIES MILLIONS/SIDE	CAPABILITIES	DETERRENCE STATUS
URBAN-INDUSTRIAL	POPULATION/INDUSTRY • (ASSURED DESTRUCTION)	TOP FEW 100 CITIES	FEW 100 (EMT)	100-200	• 1ST STRIKE: US & SOVIET CAPABLE • RETALIATORY STRIKE: BOTH HAVE SURVIVABLE URB - IND RESPONSE SUFFICIENT TO DETER	MUTUALLY DETERRED
	POLITICAL/ECONOMIC SYSTEM • INHIBIT RECOVERY	1000's OF SELECTED TARGETS - MOSTLY URBAN	100's - 1000's (MOSTLY EMT)			
	MILITARY CAPACITY • FORCES, SUPPORT, INDUSTRY	MANY 1000's TARGETS URBAN NOT AVOIDED	MANY 1000's (EMT & CMP)			
MASSIVE COUNTER MILITARY (URBAN AVOIDANCE)	• COMBINED STRIKE ALL HIGH VALVE, LOW COLLATERAL DAMAGE, MILITARY TARGETS	SEVERAL THOUSAND	MANY 1000 (SUM OF BELOW)	10 - 60	• DEPENDENT ON STRATEGIC FORCE ATTACK CAPABILITY	
	• OTHER MILITARY TARGETS (OMT) STRATEGIC DEFENSE GENERAL PURPOSE NUCLEAR STORES, ETC.	~1000 IN US ~2500 IN SU	MOSTLY EMT 1/TARGET	10 - 50	• BOTH HAVE 1ST STRIKE + SURVIVABLE RESPONSE IN KIND	MUTUALLY DETERRED
	• STRATEGIC OFFENSIVE FORCES ICBMs, BOMBERS, SLBM-IN-PORT COMMAND, CONTROL, COMMUNICATIONS	~1300 IN US ~1700 IN SU	1 or 2/PER TARGET CMP	1 - 10 SU LOW SIDE US HIGH SIDE	• NEITHER SIDE YET HAS EFFECTIVE 1ST STRIKE CAPABILITY • SOVIETS APPROACH CAPABILITY IN EARLY 80s	NO US CREDIBLE DETERRENT FOR PROJECTED THREAT
LIMITED OBJECTIVE ATTACKS "LIMITED NUCLEAR OPTIONS-LNO's"	• SELECTED FUNCTIONAL CAPACITY: MILITARY, POLITICAL, INDUSTRIAL • WIDE RANGE SCENARIOS	10's - 100's	• TARGET DEPENDENT HARD OR SOFT • SOPHISTICATED COMMAND, CONTROL	FEW TO SEVERAL MILLION	• BOTH HAVE LIMITED 1ST & 2ND STRIKE CAPABILITY • SOV CAPABILITY INCREASING • US DEVELOPING RESPONSE IN KIND TO HIGHER FORMS	MUTUAL DETERRENCE PROGRESSING WITH THREAT
EXEMPLARY OR DEMONSTRATIVE ATTACKS	DEMONSTRATE RESOLVE TO • USE NUCLEAR WEAPONS • HIT SELECTED TARGETS	ANY TARGET	VERY FEW (1-10)	FEW UNLESS URBAN TARGET SELECTED	BOTH HAVE 1ST & 2ND STRIKE CAPABILITY	MUTUALLY DETERRED

INCREASING ESCALATION ↔ INCREASING LIKELIHOOD

Both superpowers currently have the requisite number of weapons, of sufficient soft target potential (EMT), which could survive a first strike, to execute a second strike of this character. With both sides having the capability to first strike, this class of war is a current threat; but, because both sides have a survivable response-in-kind capability, each can credibly deter the other. The Soviet buildup will not appreciably affect this mutual deterrence. At worst, it may reduce the US ability to maintain a survivable deterrent to this class of war in all three legs of the US triad of bombers, submarines, and ICBMs.

Exemplary Attacks. At the opposite end of the spectrum are the scenarios which involve few, if any, casualties. Here, the parties would be demonstrating their resolve to use nuclear weapons or to attack certain target types. An attacker must reckon with the risks of some escalation here, but a substantial second strike escalation in either numbers of warheads, casualties, or the character of damage, clearly crosses the category threshhold and invites a similar response back. Provided the respondent's selected targets are of equivalent demonstrative value as those contemplated for attack by the first striker, a response-in-kind ought to deter this class of attack. That is, the first striker's perceived advantage in demonstrating must be traded off against the potential for losses and the neutralizing affect of the opponent's like response demonstration. Since a response-in-kind does not necessarily incur escalatory risks for the second striker, it is a credible response.

With only a few weapons involved in this scenario, there is no weapon survivability at issue; and, given that both sides have the capability to execute this class of attack as a first strike or as a retaliatory response-in-kind, this class of war is mutually deterred. The Soviet buildup has no appreciable effect on this end of the spectrum.

Limited Objective Attacks. At the next level of escalation is a broad range of limited attack scenarios best described by examples. One can envision a selective nuclear strike on US aircraft carriers in a given theater or worldwide. Another objective might be to cut off US military involvement in the Pacific by attacking bases from Southeast Asia to Hawaii. Attacks on selected transportation or industrial functions are possible as are attacks on some form of political function such as government control capabilities. The range of scenarios is limitless in theory and the distinction between theater nuclear war and homeland, or strategic war, becomes less clear for some scenarios. As part of the effort to provide more flexible response options, this category of warfare has received more

attention of late. While not prohibiting first use possibilities, the US interest in this class of war is clearly to build the capability to provide response-in-kind options for any level of possible attack.

At the lower end of the spectrum of these attacks, both sides have ample weapons of a moderate hard or soft target character. For scenarios involving large numbers of hard target weapons or targets requiring surgical attack with low yield-high accuracy weapons, neither side has much capability at present. The Department of Defense has been trying to gain approval of Congress to develop and deploy a greater number of hard target ICBM warheads for this class of engagement to better match the rapid rise of Soviet hard target, ICBM weapons. The US is also working on the command and control capability features that this class of war requires, such as more rapid and more flexible targeting of missiles, rapid pre-impact first strike attack characterization, and more survivable communication to nuclear forces.

In short, both sides have a limited capacity to engage in this class of warfare now, and to the extent this threat exists, the lower forms are mutually deterred. The Soviet buildup of hard target ICBM weapons poses some near term risk that the US may not be capable of a response-in-kind option, hence may lack a credible deterrent. But, the US is working on these needs and hopefully will have its deterrent in place by the time the threat seriously materializes. Further enhancing the credibility of its deterrent to this class, the US has announced the policy of "flexible response" indicating a willingness and intent to engage in this class of warfare.

<u>Massive Counter Military Attacks.</u> Although there is considerable overlap between the higher forms of limited objective attacks and the lower levels of counter military attacks, to the degree that some would merge these classes; it is useful to think of large scale attacks on military forces separately. At the upper extreme, an attack on all identifiable military forces, logistics, military R&D and industrial targets would involve better than ten thousand Soviet targets and one-half to two-thirds of that number of US targets. Such an attack is clearly urban-industrial in character and can be deterred as for other city related wars.

At the lower extreme of this category is an attack on the fewest but highest value, military targets available--an opponent's strategic offensive forces. This attack involves some 1500 to 2000 targets, most of which are extremely hard or presumed invulnerable, in the case of submarines. Between these extremes, a set of reasonably remote, or rural, military targets can be identified which if destroyed, would severely impair a side's military power while minimizing collateral damage. For example, excluding lower value military R&D, industrial, and support

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targets such as transportation; and, excluding high value military targets in urban areas such as strategic defense, nuclear stores, and some general purpose forces; there still exists a low collateral damage, high military value target set on the order of 2000-3000 Soviet and 1000 or so US targets. These shall be referred to as Other Military Targets (OMT) to distinguish them from strategic offensive forces. These are generally soft or EMT targets.

One can hypothesize low collateral damage attacks on strategic offensive forces only, OMT targets only, or combinations of both. Because both sides have the requisite number of EMT weapons to first strike the opponents OMT target structure, or to respond in kind to this attack if strategic offensive forces are not attacked, this category of counter military war is mutually deterred as a first strike. As will be shown, the OMT attack poses more danger as follow-up threat. At the upper end of this counter military spectrum, a simultaneous attack on both strategic offensive and OMT is also possible. But the key to the success of this simultaneous attack resides in the first striker's ability to draw down the opponent's strategic weapons to the point where a response-in-kind would not be possible. Thus, these low casualty, counter military attacks all hinge on the degree to which strategic forces are vulnerable.

The impact of the Soviet buildup on this one specific attack class is the crucial issue in comprehending the real military changes in the strategic balance.

<u>Casualties.</u> In all nuclear war planning, there is substantial uncertainty regarding collateral damage. The uncertainty in fatalities for strategic force attacks are particularly controversial because this affects the concept of how to deter these attacks and it affects the believability that these attacks might be attempted in the first place. Fatality estimates for attacks on US strategic forces range from as low as 200,000 prompt deaths for ICBM only attacks to twenty million for attacks on all strategic forces and command and control. Many factors contribute to this uncertainty such as what targets are attacked, how many and what kind of weapons are used, air versus ground burst, weather, and a long list of unknown effects such as ozone depletion. Current best estimates for attacks on the US are in seven million fatality range. At under one million fatalities, a strategic force attack may look attractive to a first striker in that the likely losses to be incurred from a response-in-kind to his strike might be worth the gains made by attacking. At 20 million or more fatalities, the attack approaches an urban-industrial character and the risk of a limited

urban response becomes great. There are those who choose to believe that casualties would be high, in spite of the estimates, because the continuing applicability of a city retaliation--"assured destruction" deterrent concept--would require a less costly strategic posture. This paper places the strategic force attack at the lowest end of the counterforce spectrum based on current best estimates and on the belief that if such an attack were contemplated, great care would be taken to minimize fatalities to lessen the risk of retaliatory losses.

Counterforce Capability Requirements. Even a cursory look at Figures 2 and 5 shows that both the US and USSR have only a marginal capability to attack strategic forces at present. The damage probability (Pd) values displayed beneath each column of Figure 5 represent the amount of damage that could be done to an opponent's silos if all the CMP in each force element could be evenly applied to all silos; e.g., a Pd of .8 indicates that 80 percent of all Soviet silos would be "killed" by US bombers. This Pd calculation assumes that the CMP in each force element can be optimally and evenly applied to all silos. It accounts for weapon yield and accuracy as well as silo hardness, but neglects vital factors such as reliability, command and control, defense penetration, and fratricide effects between weapons. These Pd values are still static measures in the sense that they neglect the real world dynamics, but they are useful trend indicators. The rise in aggregate Soviet Pd (.68 to .93) and the fall of US Pd (.87 to .79) reflects the fact that Soviet silos are being hardened faster than US CMP is rising but Soviet CMP is rising faster than US silos are being hardened.

With some 1,300 US and 1,700 Soviet strategic offensive force targets, most of which require hard target weapons, the Soviets have only marginally enough hard target weapons at present, accounting for reliability (less than 1 per target at .85 reliability). Even their total force aggregate damage capability would permit 32 percent survival of US silos at present. The US has about the same reliable ICBM warhead to target ratio now (less than 1 per target). Although the US currently has three times the hard target potential, mostly bomber based, US first strike capability is about the same (Pd ICBM = .3). Bombers cannot be considered good first strike weapons because of the long warning times. SLBM warheads are inefficient in a hard target role because of their low yield and accuracies.

By the end of the decade, however, the Soviets will have sufficient warheads (better than 3 per target reliable and available) to attack strategic forces and the aggregate damage probability is approaching dangerous levels for the US (Pd ICBM = .93). The US first strike threat to the Soviets will not

have increased appreciably (still about one reliable warhead per target and Pd ICBM = .4). Subsequently, silos will be shown to be more survivable than these static calculations show. The point here is that, although neither side has a strategic force attack capability yet, the Soviet forces are moving in that direction and will achieve capabilities by the end of the decade which should cause the US to carefully examine its ability to deter this form of engagement. The US forces will pose no more of a first strike threat to the Soviets by then than they do now.

III. THE DYNAMIC BALANCE: FORCE EXCHANGES

There are many possible attack scenarios involving a wide range of variables such as alert rates and weapon employments. To focus on the major factors of the dynamic counterforce balance, a set of limiting cases will be examined using the same attack scenario over the decade. Weapon capabilities and numbers, and target hardness and numbers, vary over the decade consistent with actual or projected capability. A US conservative view will initially be adopted as the proper way the US must analyze its deterrent posture.

Attack Scenario. Consider a surprise Soviet attack on US strategic offensive forces: bombers, ICBMs, SLBMs in port, and command and control facilities. The limiting case is a maximum attack in which the Soviets set aside a reserve force for Urban-Industrial deterrence but attack with all remaining weapons. A surprise attack, under US conservative assumptions, means that no advance warning occurs sufficient to increase bomber alert rates or to deploy more submarines out to sea; but, tactical warning of the attack from radar and satellite sensors does permit the alert bomber force to escape. The US, then, is assumed to be at a normal alert status. The first striker would obviously be at a generated alert status. The standard scenario has enemy SLBMs attacking US bomber bases because these are soft targets suited to SLBM weapons and because warning time can be minimized by launching close to US shores. Even with the most severe SLBM threat, analyses show that a substantial fraction of the bomber alert force can escape. This analysis assumes that ten minutes or so of warning time permits all the alert force to escape. (In a coordinated attack in which SLBMs and ICBMs are timed to arrive together, more bombers escape due to the longer warning times provided by the ICBM flight times.) On warning, it is assumed the bombers are automatically launched - their specific target destinations to await the selection of an overall response decision. SLBMs in port, if attacked, are assumed killed as are non-alert bombers. In all

cases considered, both sides preserve an assured destruction city reserve as a first priority, in order to prevent escalation above the counterforce threshhold. A major assumption is that sufficient command and control remains to execute the options desired by both sides.

For this attack scenario, the US must make two key decisions in determining its response. First, what response option provides the best US outcome, i.e., limits US damage while inflicting hopefully unacceptable losses on the opponent yet holding the conflict to the lowest possible level. If good options exist for the US, these ought to provide credible deterrence in the first place. Second, does the ICBM force need to be launched prior to the attack arrival or can it be permitted to ride-out the attack. A need to launch-on-warning (or more precisely - to launch before impact after attack assessment confirms a large attack on US silos) removes substantial US flexibility because: it forces a pre-programmed response, cuts short the decision time, and requires a decision under severe uncertainty. Namely, there would be uncertainty about the enemy's intent, uncertain knowledge of US losses, and uncertainty in what enemy forces remain. A need to launch-on-warning does not help the cause of stability in crisis situations.

If a response involving predominantly soft targets is selected, a launch-on-warning is not mandatory. SLBM weapons, assumed invulnerable, can handle most EMT or soft target responses, assuming that SLBM forces can be commanded. If a hard target option is selected, airborne bombers provide a measure of capability if the response is not time critical. If the response involves time critical hard targets, such as silos, or if SLBMs are not assumed commandable, then a decision to launch the ICBMs on warning will depend on the degree to which expected ICBM losses affect the response. To highlight this decision, both the launch-on-warning and the ride-out option results will be shown in these exchange calculations.

The results of three US counterforce response options will be shown. As previously discussed, counterforce responses are the only credible deterrents. Escalation to an urban-industrial war risks a like response on US cities. Lower forms of responses are not able to inflict losses on the opponent of the same order as the first strike without involving an escalation in the level of casualties. Of the three response options, two are limiting cases: (1) a maximum US response-in-kind on Soviet strategic forces; and (2) a response on all Soviet OMT. The third option, a combined response on strategic and OMT forces would at best be the sum of these two limiting cases were enough weapons available. With limited weapons, the combined response results

in less strategic force and OMT damage than the limiting cases, the degree of damage dependent on which target class receives the most weapons. Only one of the many permutations of this third option will be shown: a response which allocates 80% of the required weapons to the OMT target structure; and the remaining weapons, over and above the Urban-Industrial reserve, are used to attack strategic forces. This option can either: (1) withhold OMT weapons to (a) deter OMT escalation by the opponent or (b) provide the flexibility for the US to escalate to OMT at a subsequent stage; or (2) it can escalate immediately by simultaneously responding on both OMT and strategic offensive forces. This third option approaches an optimum or best response, hence it represents a most likely US response.

Strategic Force Attack. Figure 8 displays the exchange results for a maximum Soviet attack on US strategic forces for three points over the decade (straight line interpolation between these points). The top figures show the first striker's component and total warheads and his allocation to the attack force or reserves. Below are the US total and component weapons, losses, allocation to reserve, and availability for response. The two limiting counterforce response options, and the representative most likely response are arrayed below showing: the US weapons used and delivered to target, and the final balance for both sides at the completion of the first round - first and second strike. Damage, either inflicted or capable of being inflicted subsequently, is displayed for each response option in terms of percent of the target structure destroyed. Equal percentages do not reflect the same number of targets destroyed since the target sets are asymmetric.

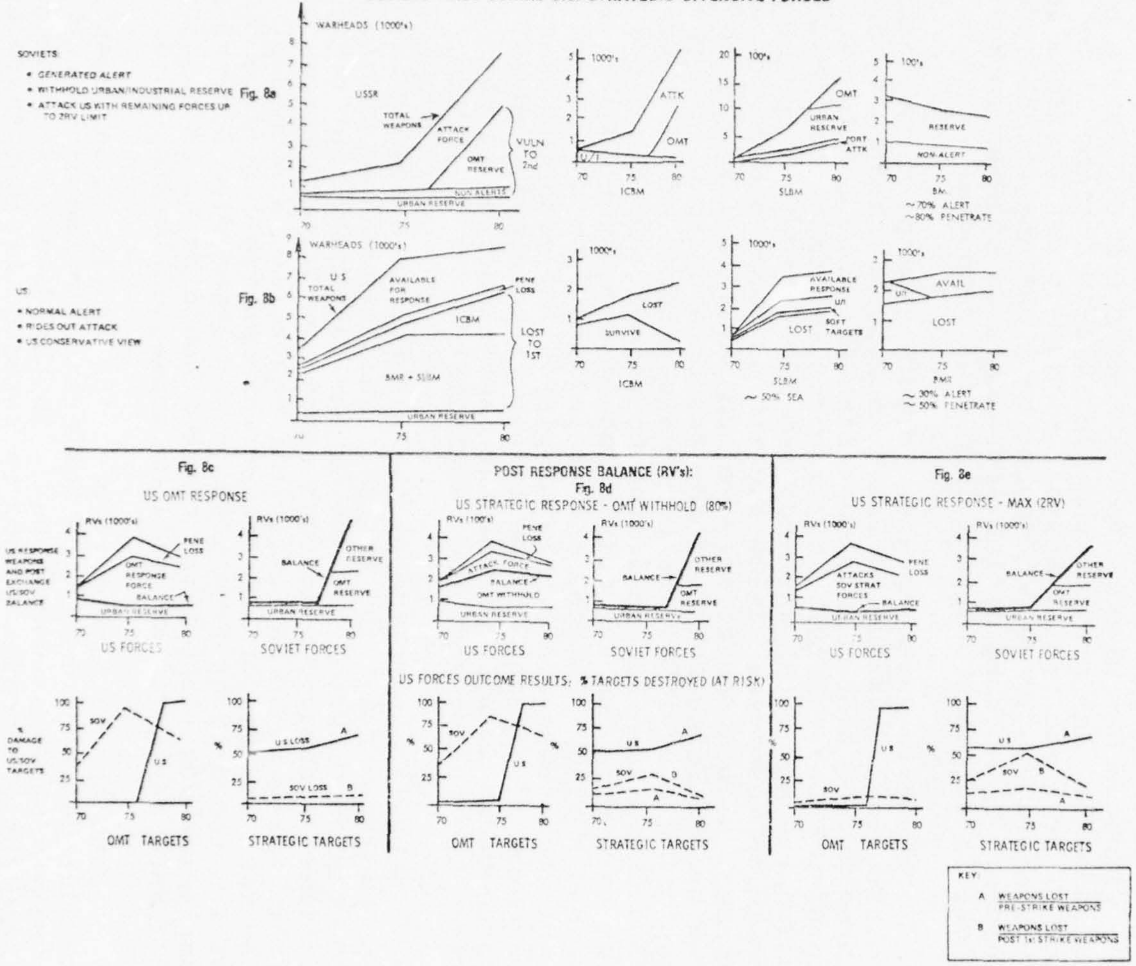
A basic assumption of the 2nd strike response is that the opponent rides out the attack. This assumption is reasonable for these scenarios because of the assumed intent to minimize collateral damage. Although a maximum Soviet attack, as postulated here, is not an efficient attack in the sense of achieving the most damage for the fewest weapons used; it is a proper attack to consider from a US conservative view because it represents the worst the first striker could do to US strategic forces. A lesser Soviet attack will be subsequently discussed.

From the total operational (on-line) weapon inventory, the top line of Figure 8a, the Soviets set aside an urban-industrial reserve force as shown. Early in the decade, weapons from all three force components must be reserved because there are insufficient SLBM weapons - the least vulnerable. At the close of the decade, no ICBMs are required for the urban-industrial reserve. It is assumed that Soviet bombers would not be used in the first strike because the long flight times provide warning of attack.

Figure 8

COUNTERFORCE EXCHANGE

SOVIETS FIRST STRIKE U.S. STRATEGIC OFFENSIVE FORCES



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There is a possible bomber threat, not addressed in this analysis, that sufficient numbers of Soviet bombers could penetrate the limited US air defense system - UNDETECTED - to attack US bombers and command and control aircraft on the ground.

On-line but not ready forces, such as SLBMs in port and non-alert bombers, are considered unavailable for attack or reserve for both sides. About one hundred SLBM warheads are used to attack US bomber bases and SLBMs in port. The rest of the attack is conducted using Soviet ICBMs; in effect, the first strike is an ICBM duel-Soviet ICBMs vs US ICBMs. Through mid-decade, there are insufficient reliable attacking ICBM warheads to cover all US targets; but by the end of the decade, there are enough Soviet RVs for more than one weapon per target.

Fratricide. Recent analyses have shown that multiple weapon attacks on a single target and nearly simultaneous attacks on an entire missile field are next to impossible to execute without causing a fratricide effect: one weapon destroying another or knocking it off course. About the best that can be done is to place two weapons (RVs) on a target in a particular way so as to compound the damage probability, while minimizing fratricide. Assuming an opponent has a 2 RV per target capability gives him credit for very sophisticated command and control, time on target control, reliability make up or retargeting system, and other difficult technical capabilities. But, from a US conservative position, the 2 RV capability is the necessary safe assumption. There is no known technical reason to preclude such a Soviet capability. After achieving a 2 reliable weapons per target attack capability late in the decade, the remainder of the Soviet ICBM force is held in reserve for other strategies such as a counterforce OMT attack. No SLBM weapons are assumed used in the first strike on US silos because not enough are available through mid-decade and because none are needed later.

Pin-Down. There is an often discussed pin-down strategy involving SLBMs in which US ICBMs are prevented from launching prior to the arrival of the main attack by detonating SLBM warheads such that US missiles would be destroyed on lift-off or fly-out if they were to be launched on warning. This attack strategy is considered here in that only the results of the US ride-out responses would be valid if the pin-down is feasible and used.

US losses, survivors, reserve allocations, and weapons available for response are given in Figure 9b. If all ICBMs were launched on warning, the number shown as lost to the first strike is added back to those shown as available for the response.

The US assured destruction reserve requires the use of most of the alert bomber force early in the decade. Of course, for either side, if the number of reserve weapons required is perceived to be different from the 500 or so depicted here, these reserve allocations would change. About the same number of US SLBM weapons are used to attack Soviet subs in port and bomber bases for the Strategic Force response options.

<u>OMT Response.</u> If the US rode out the maximum attack and chose to respond on Soviet OMT only, Figure 9c shows that an increasing amount of damage could be done to the Soviets through mid-decade, whereas the Soviets would not be able to subsequently damage US OMT, having used all available weapons attacking strategic forces. Because US Bomber alert rates were actually higher early in the decade than shown here, the actual OMT damage potential would have been closer to 50% (vs 30%) for the postulated 2400 OMT target set. Even though a US OMT response would be escalatory, it meets the credible deterrence criteria of inflicting unacceptable damage while mimimizing risks of counter escalation because the Soviets would not have the capability to respond-in-kind. Only an Urban-Industrial response is available to them but at the risk of similar US subsequent response. It is not reasonable to believe that the loss of most of the Soviet OMT is worth the gains of this first strike. The only real Soviet gain would be the destruction of half the US strategic forces and a leveling out of the warhead balance if the US used the OMT response. In fact, if the US did not actually retaliate on Soviet OMT but only held their OMT hostage, the US would be in a better position after the attack than before, excluding of course, the fatality considerations. Therefore, it is reasonable to argue that, prior to the end of the decade, a US OMT response alone ought to deter this maximum strategic force attack. If the US were to launch-on-warning, although not required for deterrence, the Soviet OMT losses would increase.

The effect of the Soviet buildup on this OMT only response option is vividly clear by the end of the decade, however. Now, in addition to the increased damage to US strategic forces (to 60-70%), the Soviets have sufficient warhead reserves to subsequently respond on US OMT. This denies the US the capability to use the OMT response as a credible deterrent because executing this response risks a counter escalation clearly not worth the advantages of a Soviet response.

A launch-on-warning for an OMT response at the end of the decade would reduce US strategic losses (to about 40%) and increase Soviet OMT losses, but this has no practical value since the OMT response is deterred. The US must rely on some other response for deterrence at the close of the decade to this postulated attack.

Strategic Force Response. The other limiting response case is shown in Figure 9e. Here the US tries to respond-in-kind by attacking Soviet strategic forces with all surviving weapons over and above the Urban-Industrial reserve. Again, the resulting balance is shown to be about even in warheads. Both sides maintain mutual deterrence for Urban-Industrial war. Few OMT targets are killed or threatened for either side throughout most of the decade. US strategic force losses are proportionately about the same over most of the decade (50-70%). Even while riding out the first strike, the US has the capability to inflict some damage on the Soviet strategic forces, comparable in terms of percent of remaining forces, but much less in terms of total forces (pre-strike forces) because so few vulnerable Soviet weapons remain through most of the decade. Aside from the Soviet subs in port and non-alert bombers killed, a US strategic force response through mid-decade amounts to killing empty silos. While not completely without value, this credible response does not possess much deterrent power in terms of loss inflicted for loss absorbed. A launch on warning early in the decade does not appreciably alter this situation. These results merely demonstrate that this maximum strategic response is not a particularly good one for the US especially when the OMT response is still available for use, prior to the close of the decade. At the end of the decade, US strategic force losses increase, in particular the ICBM force in which resides most of the deliverable hard target potential (CMP). Now, even though thousands of Soviet weapons remain in silos, vulnerable to attack, the percent damage of the response declines because so few hard target weapons survive and penetrate (60-70% US losses vs 20-25% Soviet losses). Those that do attack are further diluted in effectiveness because knowledge of empty vs full silos is not available under the assumptions of these calculations. In addition to the rapid decline in strategic damage potential as shown, the Soviets now have sufficient surviving weapons after absorbing the second strike to place the US OMT target structure in a hostage or coercive situation. Under this maximum strategic response, the US would have few weapons left to neutralize this hostage capability. Thus, not only is this US response weapon inefficient, but also bad strategy. In fact, at the end of the decade, this US response could provide the Soviets a motivation to attack. This outcome would make the US susceptable to total coercion short of urban war.

A launch on warning, maximum strategic response at the end of the decade (not shown) rectifies the strategic force damage inequity (40% damage each side) and, given the same 2 RV limit, offsets the Soviet OMT hostage potential to some degree (100% US OMT in hostage vs 40% Soviet OMT in hostage). It is the only

option so far considered that has a hope of providing a credible deterrent in the future. Thus, the Soviet buildup can be seen as having denied the US a reasonably safe escalatory deterrent (OMT response) and reducing our flexibility to ride out a maximum strategic attack.

Combined Countermilitary Maximum Response. In the above strategic force response, many SLBM weapons were used to attack Soviet silos late in the decade to achieve a maximum damage limit. This is an inefficient use of weapons and it places the US in a hostage position late in the decade. A better US response would be to attack strategic forces using only hard target weapons and reserving soft target weapons to neutralize the Soviet OMT reserves. Figure 9d shows the third response option in which the US withholds 80% of its OMT requirements as well as the Urban-Industrial reserve and responds on Soviet strategic forces with the remainder. Early in the decade there are insufficient surviving weapons over and above these reserves to attack silos, but these are mostly empty anyway. Only the bomber and subs in port are attacked resulting in little damage to Soviet strategic forces. The 80% OMT requirement cannot be met. At mid-decade, the OMT reserve can be met and the strategic force damage rises as a percent of remaining Soviet forces (from 15 to 30%). This is possible because many US ICBMs still survive. Again, this response is largely an attack on empty silos through mid-decade. The most important time for this response to be successful is at the close of the decade. The OMT reserve able to be generated (60%) is probably sufficient to prevent a US hostage condition here but the amount of damage to strategic forces is very low (about 10%) and by this '80 time frame, thousands of reserve Soviet weapons remain. Overall, this response would probably deter a maximum Soviet attack through most of the decade relying in the main on the OMT deterrent part not the strategic force damage. At the end of this decade, the OMT deterrent credibility is gone and the strategic force damage potential is not enough to inflict unacceptable losses (70% US loss vs 10% Soviet loss).

A launch on warning response for this OMT withhold attack is mandatory by 1980 to reduce US strategic damage to the 40% level and to increase Soviet strategic damage to the 30% and 45% of total and remaining force levels, respectively.

Pre-Buildup Outcomes. This analysis is mainly concerned with the US' view of its deterrent capability but an interesting result can be seen by looking at the Soviet point of view of these outcomes. Prior to the full realization of the Soviet buildup in the late '70s, this hypothesized, all-out, strategic force attack on the US would be a severe mistake for the USSR.

At best, from a Soviet view, the US would ride-out the attack and try to respond-in-kind on their few remaining strategic forces. The outcome would be a net draw: both retain assured destruction forces; the Soviets destroy about half the US weapons and absorb percentage losses of half that much. But, while Soviet losses may be acceptable, it is difficult to determine a meaningful military advantage for the Soviets in this best of outcomes. On the other hand, the risks involved in such an attack are substantial. If the US were to respond by attacking Soviet OMT, either after riding out or launching on warning, substantial losses would be inflicted on non-strategic military forces and fatalities could be very high. The US would have no reservations escalating to OMT without a Soviet counter-escalation capability below the Urban-Industrial threshhold. The US could also destroy a mix of strategic forces and OMT which, cumulatively, would impose unacceptable losses relative to the limited first strike gains. Alternatively, the US could respond on some strategic forces but hold off an attack on OMT placing the Soviets in a position of not only weapon inferiority, but total inability to deter all other, non-urban attacks. Soviet other military targets would be hostage to the US strategic forces. In short, there are no outcomes favorable to the Soviets and many outcomes which could be defined as Soviet losses. At best, even using the US conservative assumptions of these calculations, the postulated maximum strategic attack comes out a "draw" for the Soviets, pre-buildup.

It should be obvious at this point that if the Soviets attempted a strategic force attack prior to their force buildup but withheld OMT weapons to prevent an OMT response or an OMT hostage outcome, there would be few weapons available to attack US strategic forces. They could thus reduce the risks of US OMT responses but could inflict no appreciable US ICBM losses and would suffer unacceptable ICBM losses in return.

Thus, pre-buildup (pre-1980), the Soviets have no credible counterforce first strike capability even using US conservative assumptions - i.e., those least favorable to the US. The Soviets must adopt a second strike policy which, indeed, is consistent with espoused Soviet doctrine and rhetoric. From a US point of view, there exist several credible counterforce response options which offer good deterrent potential. In no case is a launch on warning mandatory for outcomes which ought to deter. The US posture therefore provides adequate decision flexibility, even if deterrence should fail. There is no way for the US to get into a position of inferiority. At worst, the US would respond into a draw. Hence, from the US view, massive counterforce attacks have been and are now deterred as are other forms of strategic war.

Post-Buildup Outcomes. At the end of the decade, the situation will have changed appreciably. From the Soviet view, there are several favorable outcomes of a strategic force attack. If the US rides out the attack and tries a maximum response-in-kind on the many remaining USSR weapons, the Soviets would achieve a coercive position over the US (100% vs 10% OMT in hostage; 70% vs 20% strategic force damage). This result could be interpreted as a Soviet "Win," as difficult as win-lose definitions are in strategic engagements. If the US preferred to absorb the strategic losses and not respond in any massive way, attempting to preserve the post-attack warhead balance, this would also be a Soviet "win" in the sense that no damaging response or counter strategy is a de-facto admission of inferiority and is bound to be interpreted as such politically.

The risks to the Soviets in the near future will be comparatively low. A US OMT response--alone or with strategic forces--is a Soviet risk but could only be executed by the US at the risk of its own OMT destruction. This US response ought to be deterred from the Soviet viewpoint. A US response on strategic forces withholding OMT weapons would deny the Soviet coercive counterforce strategy but would inflict only token strategic force damage (70% US vs 10% Soviet). At worst, a US launch on warning on strategic forces, withholding appropriate reserves, would result in nearly equal damage to both sides (about 40%) and the post-exchange warhead balance would slightly favor the Soviets. Thus, by the end of the decade, the counterforce outcomes have reversed from the Soviet view. At worst, the outcome would be a draw; at best, a capability to coerce the US could result. There is even a small chance of no US response.

From the US view, this first strike is no longer deterred with confidence. If the US rides-out the attack either by choice, through indecision, because of loss of command and control capability, because the missiles are pre-targeted at the wrong targets, or for whatever reason, only the capability to prevent further escalation to other military targets exists by preserving an OMT withhold. The US could not inflict unacceptable or even comparable damage on Soviet strategic forces. Thus, while maintaining an ability to deny the Soviets a meaningful advantage, the US no longer can provide the damage criteria comparable to present standards of credible deterrence. Only a US launch on warning at strategic forces withholding urban and OMT reserves has the potential to lessen US losses, increase USSR losses, and prevent escalation to OMT engagement or neutralize the OMT coercive counterforce strategy.

Summary of Outcomes. The Soviet buildup provides them with a capability, for the first time, to execute a counterforce attack which is both rational and credible. It is rational in the sense that there are outcomes which could provide a clear political Soviet advantage (US in hostage) - if not a "win." It is credible in that the risks of Soviet losses are low and these may well be deemed worth while risks in major crisis situations. At best, the Soviets could achieve a coercive superiority over the US. At worst, their strategy fails and the outcome is a draw with the US absorbing more losses. The US ability to deter such an attack depends, in essence, on the credibility of a US launch on warning. Even then, the damage potential may not be sufficient to deter. Since deterrence is the primary purpose of US forces, not the ability to win an engagement or deny an opponent's advantage (not lose), the US must be capable of inflicting greater losses on Soviet strategic forces in the near future. To accomplish this, the US must increase its surviving hard target potential by adding more hard target weapons to its force, by improving the survivability of the existing hard target forces, by improving the effectiveness of existing countermilitary forces, or all of the above.

The Soviet buildup provides them a new capability to engage in the full spectrum of counterforce engagements and at the same time denies the US a previously credible escalatory deterrent option, forcing a reliance on a possibly unachievable launch on warning response-in-kind. Before addressing what specific actions the US can take to strengthen its deterrent, these outcomes and conclusions must be placed in a broader perspective.

Engagement Perspectives. Unfortunately, no single set of calculations or exchange results can describe the true dynamic balance. Uncertainty in one's own and the opponent's capabilities forces each side to consider how an engagement might look to both sides. Figure 9 depicts four perspectives that must be considered before a final assessment can be made. The preceeding analysis focused on the US' view of its own ability to deter a Soviet first strike - a US Defense conservative view. These conclusions showed no cause for alarm until the end of the decade, when, from the US point of view, a Soviet attack could be executed with minimal risks. The Soviets, however, must assess both their capability to attack and the effectiveness of possible US responses based on their own offense and defense conservative assumptions. With no knowledge of real Soviet assumptions, the US can only approximate a Soviet conservative view using a different set of force capability values and scenario assumptions. These differences are shown, in general, in Figure 9.

Figure 9

DYNAMIC BALANCE PERSPECTIVES

	SOVIET FIRST STRIKE	US FIRST STRIKE	TREATMENT OF UNCERTAINTY
DETERRENCE VIEW	US DEFENSE CONSERVATIVE	SOV DEFENSE CONSERVATIVE	US CONSERVATIVE:
OPPONENT'S 1ST STRIKE CAPABILITY	SOV - GENERATED ALERT US - NORMAL ALERT	SOV - NORMAL ALERT US - GENERATED ALERT	SOV - HIGH SIDE US - KNOWNS/LOW SIDE
WARFIGHTING VIEW	SOV OFFENSE CONSERVATIVE	US OFFENSE CONSERVATIVE	SOV CONSERVATIVE(US VIEW):
OWN 1ST STRIKE CAPABILITY	SOV GENERATED ALERT US GENERATED ALERT	US GENERATED ALERT SOV GENERATED ALERT	US - KNOWNS/HIGH SIDE SOV - BEST/LOW SIDE

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In effect, the outcome results of Figure 8 must be completely recalculated to approximate the Soviet view of the same force exchange. If the Soviet attack still looks attractive from their viewpoint, then the previous conclusions relative to waning US deterrence are strengthened. If an attack no longer looks attractive from the Soviet conservative view, then a judgement must be made on whether deterrence should rely on estimates of Soviet conservatism. It is impossible to avoid these judgements.

A balanced view of the Soviet buildup and its impact on the counterforce balance must also take into account how the Soviets may view their deterrent to a preceived US first strike capability. Their buildup may well be aimed at improving their own deterrence to a similar set of exchange calculations and scenarios.

Without displaying the results of these other force exchange calculations, the outcomes can be summarized as follows. In the pre-1980 era, a Soviet counterforce first strike does not look good from the Soviet viewpoint. The outcomes are much less favorable to the Soviets than those already described using a US viewpoint. After their force buildup, and under selected conditions, a counterforce first strike enters the realm of the possible. If the Soviets could prevent giving strategic warning to the US, implying a gradual increase in their at-sea SLBM deployment rates, and if the US ICBMs rode-out the attack, they could achieve 45% damage levels on US strategic forces while absorbing, at worst, 25% strategic force losses themselves (assuming a maximum US strategic force response). They would retain an urban and nth country reserve and enough weapons to threaten all US OMT vs a US OMT retaliatory capability of about 50% of the Soviet OMT target structure. In effect, they could achieve about a 2:1 damage ratio on both US strategic and OMT targets. While less favorable than the 3:1 damage ratio obtained under US conservative assumptions, this outcome is not one that could be viewed as unfavorable to the Soviets.

If the US could launch all its ICBMs under attack, however, the damage ratio reverses from the Soviet view: 40% damage to remaining Soviet forces vs 25% damage to US strategic forces; OMT exchanges equally deterred. Here again, it would appear that a credible US launch-on-warning capability is mandatory for an effective deterrent. This result is similar in effect to what a US first strike looks like to the Soviet planner--not a decisive US outcome but neither can the Soviets feel comfortable if they have similar views of deterrence. But they can be more comfortable with these outcomes than the US can be under the

mirror image condition. These results raise the dilemma familiar to all counterforce war gamers - that neither side can enhance stability by pursuing its own best interests of a secure deterrent potential. But neither can either side unilaterally lower its deterrent. SALT has not been successful in avoiding this dilemma by lowering force levels below the counterforce threshhold.

In summary, counterforce deterrence for the US would appear to rely heavily on the ability to launch-under-attack from either a US or a Soviet viewpoint in this 1980 time frame. While a case could be made that the US can deny the Soviets major advantages in a first strike by a carefully selected response; nevertheless, US deterrence ought not rely on a judgement of how the Soviets treat uncertainty and what their perceptions of relative advantage might be. US deterrence must be based on certain knowledge that the rational Soviet planner will find the outcomes totally unacceptable.

IV. CONCLUSIONS

US Force Posture Implications. One thing the US can do both to enhance its deterrent and to contribute to crisis stability is to avoid the need to launch-under-attack. While this paper has made a case that the US must develop this capability and policy to insure counterforce deterrence, this is not to say launch-under-attack is the best course. Such a response could have disastrous consequences if the US miscalculated the intent of a less ambitious Soviet or nth country first strike by overresponding, thereby escalating the conflict beyond need. Furthermore, a launch-under-attack capability may be beyond the state of the art. That is, the ability to provide high confidence assessment that at least strategic forces are under attack, to communicate this fact to the National Command Authority - hopefully in a survivable facility, to provide time for his response decision, to communicate this to the forces, to target the forces and command launch, and to achieve safe missile fly-out, all pre-impact, is not a simple technical problem. And, if one adds the SLBM pin-down threat or SLBM attacks on communication nodes or the attack characterization sensors themselves, the problem becomes difficult indeed.

There are other options for the US than launch-under-attack. To list a few of the more obvious ones, increased bomber alert rates can add substantially to the survivable hard target weapon inventory. This could be accomplished today with sufficient operating funds. Increased SSBN at-sea rates could help the

counterforce capability somewhat by reducing the need to reserve hard target weapons (bombers and ICBMs) for the soft target requirements. Alternatively, improved intelligence sensing may be able to provide the strategic warning needed to increase these same alert rates before the conflict begins, and thereby, possibly prevent it.

In the intermediate range, the B-1 bomber will provide improved counterforce deterrence. By being capable of higher ground alert rates; with faster escape time and increased nuclear hardness giving greater survivability; with its low altitude and advanced electronic warfare capability providing greater defense penetration; and with its greater weapon load; the B-1 can deliver 3-4 times the weapons to target than the present bomber force. In a scenario where a first striker is withholding ICBM weapons to prevent a hostage condition or to preclude escalation, it is reasonable to assume he would not launch a second wave ICBM attack against a new target set; hence, the bombers could credibly attack silos in a second strike mission.

Increasing the survivability of the ICBM force, the source of the counterforce instability, is the most direct fix. Some argue that by doing away with the land based missile force, the counterforce problem can be solved. The primary counter argument is that only the ICBM force provides the highly controllable, highly accurate, time critical force capability required for selective and limited nuclear responses. SLBMs, as invulnerable as they presently are, cannot remain both undetectable and readily commandable, nor can their weapons be effective against hard targets until the era of terminally guided, maneuvering reentry vehicles - probably in the late 1980s at the earliest. Two approaches to increased ICBM survivability are under examination by the US. A third approach - greater silo hardness - is believed to have reached its practical limit. The first approach is the one taken by the Soviets: increasing the throw weight of each silo based missile and MIRVing these weapons with 6-10 hard target RVs. This approach does not help the missile survivability problem, but those that do survive will have improved hard target potential. If too many silo missiles are so equipped, this force takes on a threatening first strike appearance, reducing stability. In effect, this is what the Soviets have done and this is the cause of the counterforce problem. But, at best, this approach only postpones the time by a few years when a launch-under-attack requirement is needed to keep pace with the ever increasing Soviet ICBM accuracies.

A second approach is the land mobile ICBM, or in the context of US thinking, an alternate-based missile. Purely ground mobile systems have been rejected by the US largely because of the unfavorable public reaction anticipated. The US basing concepts achieve their survivability by proliferating aim points - either through low cost shelters (a shell game approach) or by line targets (buried trenches). Air-mobility has not yet been ruled out. If properly designed, this less vulnerable ICBM could provide enough surviving hard target weapons to deter a counterforce strike while not simultaneously possessing a first strike - counter-silo capability itself. And, it can provide the commandability and accuracy required for selective responses. This M-X program would appear to be the best US approach for deterring the counterforce strikes addressed by this paper. The problem is, it probably cannot be deployed before the Soviet counterforce threat becomes even more severe than described herein.

There are, of course, many other US force posture fixes of a less dramatic nature to include some of the Dymamic Battle Management capabilities discussed previously. The US is looking hard at what combinations of capabilities it can afford while still trying to pursuade the Soviets at SALT that meaningfully lower force levels are of mutual interest.

Conclusion. The Soviet strategic force buildup may lead to perceptions of Soviet superiority at least by the end of this decade. Commonly available static measures of force capability all point to Soviet superiority by 1980 or shortly thereafter. If the momentum of this ten year change continues into the '80s, as the US expects it will, serious political problems await the West. The Soviets may already be flexing their new muscle in Africa.

From a military viewpoint, the US no longer can rely on its nuclear forces to deter all classes of strategic wars - the clean counterforce attack specifically. The nuclear umbrella is leaking. The combination of a new silo-based MX missile with appropriate hard target RVs and subsequently, an alternate-based, less vulnerable M-X, appropriately sized, may be able to repair the US deterrent in time. If not, the US must develop the ability to and declare the will to launch its ICBMs at Soviet strategic offensive forces when confident that such a first strike is underway at the US.

Alternatively, the US could give up its policy of Flexible Response at the risk of catastrophic consequences should deterrence fail. Perhaps SALT III can resolve the counterforce problem. Judged by Soviet actions, this would appear to be a faint hope. The US must take actions to improve its counterforce capabilities both to nudge the Soviets into cooperation and to protect its deterrent if this fails.

THE STRATEGIC NUCLEAR BALANCE

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MAJOR POINTS REGARDING U.S. STRATEGIC FORCES

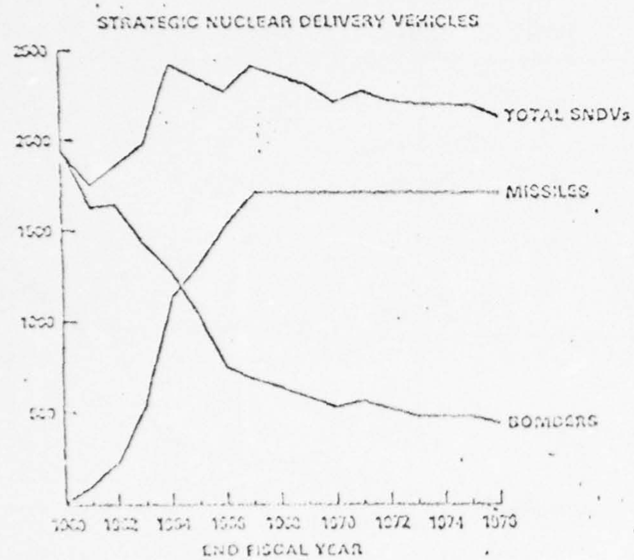
- o. OUR STRATEGIC FORCES ARE SURVIVABLE AND EFFECTIVE TODAY - OUR CONCERNS ARE FOR THE FUTURE.

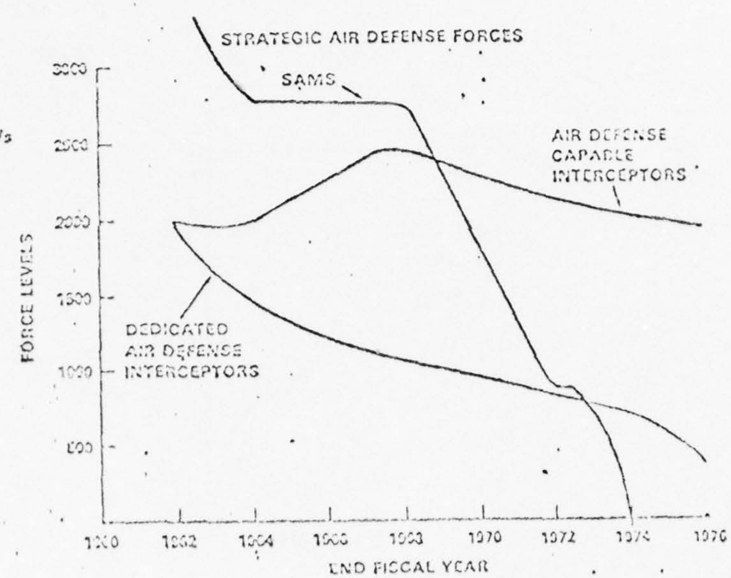
- o. WE SPEND 10-15% OF THE TOTAL DoD BUDGET ON STRATEGIC FORCES, BUT MUCH OF THE DEBATE FOCUSES ON STRATEGIC SYSTEMS.

- o. WE CANNOT ACHIEVE A MAJOR SPENDING CUT IN STRATEGIC FORCES WITHOUT AFFECTING THE CONFIDENCE IN OUR DETERRENT - EVEN WITH ACHIEVEMENT OF AN EQUITABLE SALT II AGREEMENT.

- o. THERE IS JUSTIFICATION FOR B-1 AND TRIDENT PRODUCTION - AS COST-EFFECTIVE REPLACEMENTS FOR AGING SYSTEMS. THESE SYSTEMS WILL CAUSE AN INCREASE IN THE FY 77 BUDGET COMPARED TO FY 76.

HISTORY OF STRATEGIC FORCES





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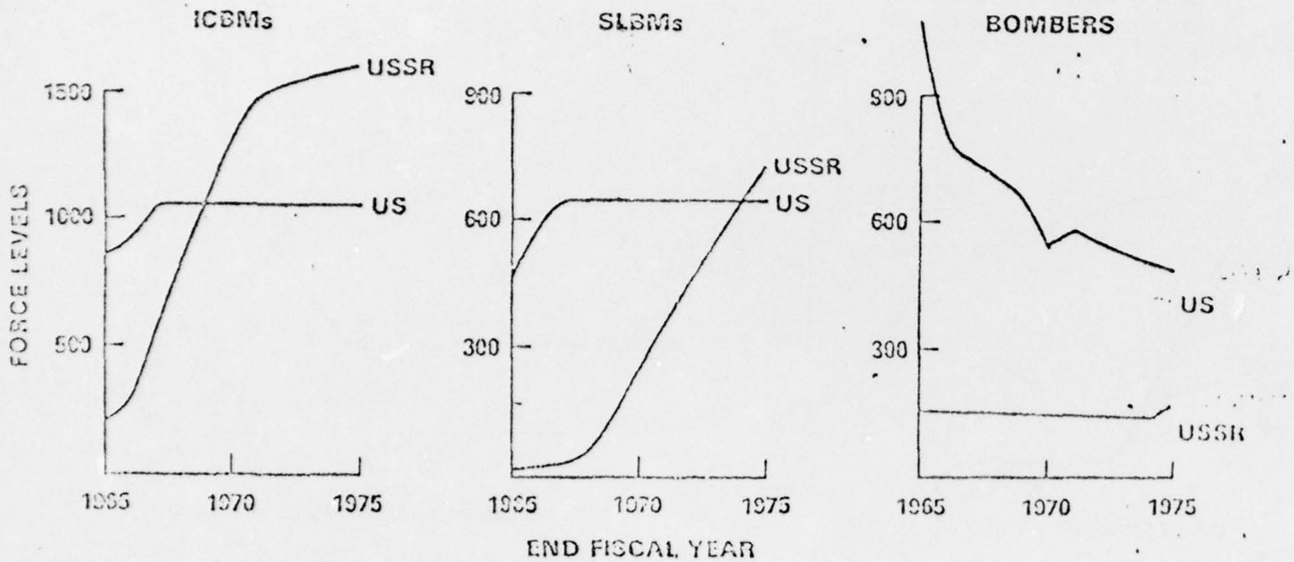
HISTORY OF THE THREAT



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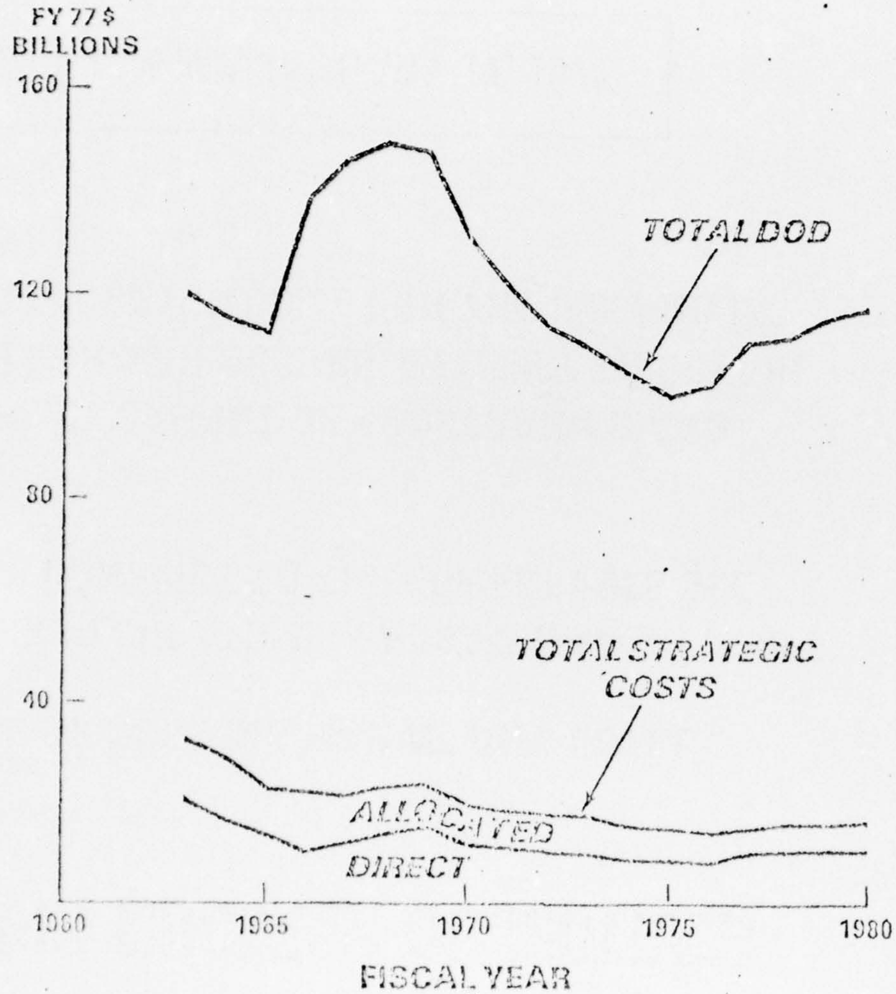
STRATEGIC [illegible] SPENDING WILL CONSUME 10-15% OF TOTAL DOD SPENDING



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STRATEGIC NUCLEAR OBJECTIVES

- DETERRENCE OF NUCLEAR WAR AT ANY LEVEL
- IF ENEMY MISCALCULATION LEADS TO WAR, ATTEMPT TO LIMIT THE CONFLICT TO THE LOWEST POSSIBLE LEVEL
- IF THE CONFLICT CANNOT BE CONSTRAINED AND MAJOR NUCLEAR WAR OCCURS, ATTEMPT TO OBTAIN THE BEST POSSIBLE OUTCOME FOR THE U.S. AND ITS ALLIES

BASIS: NSDM-242, JANUARY 17, 1974

Planning Criteria for Ensuring Strategic Deterrence

- o The sole objective of our strategic forces is to provide deterrence.

- o It is <u>essential</u> that a major element of our strategic deterrence includes strong General Purpose forces to deter those conventional conflicts which might lead to nuclear war.

- o Our strategic forces provide deterrence by:
  - Ensuring an effective survivable retaliatory capability against our threatening adversaries.
  - Presenting an overall capability which is not inferior to that of our adversaries.
  - Providing sufficient response flexibility to permit termination of hostilities at any level and, thus, ensure U.S. capability to control escalation.

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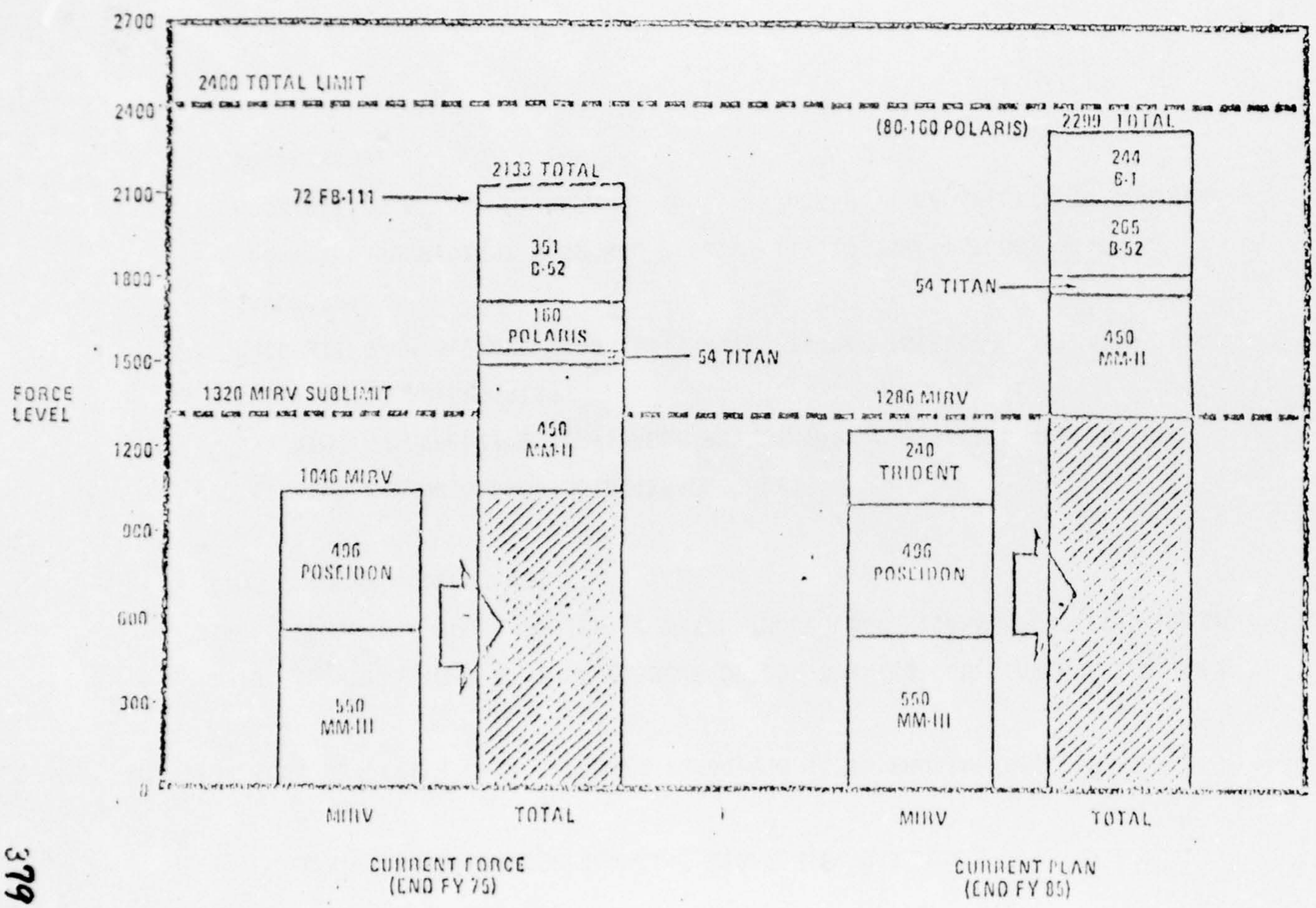
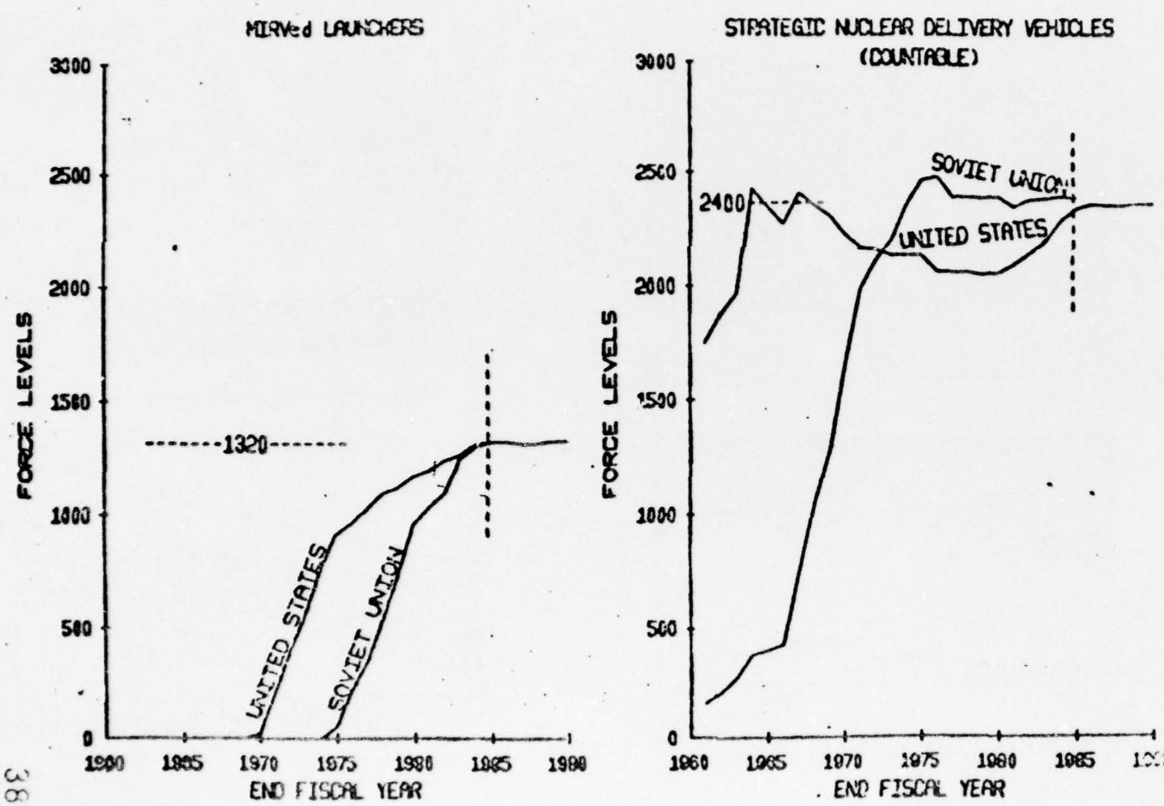
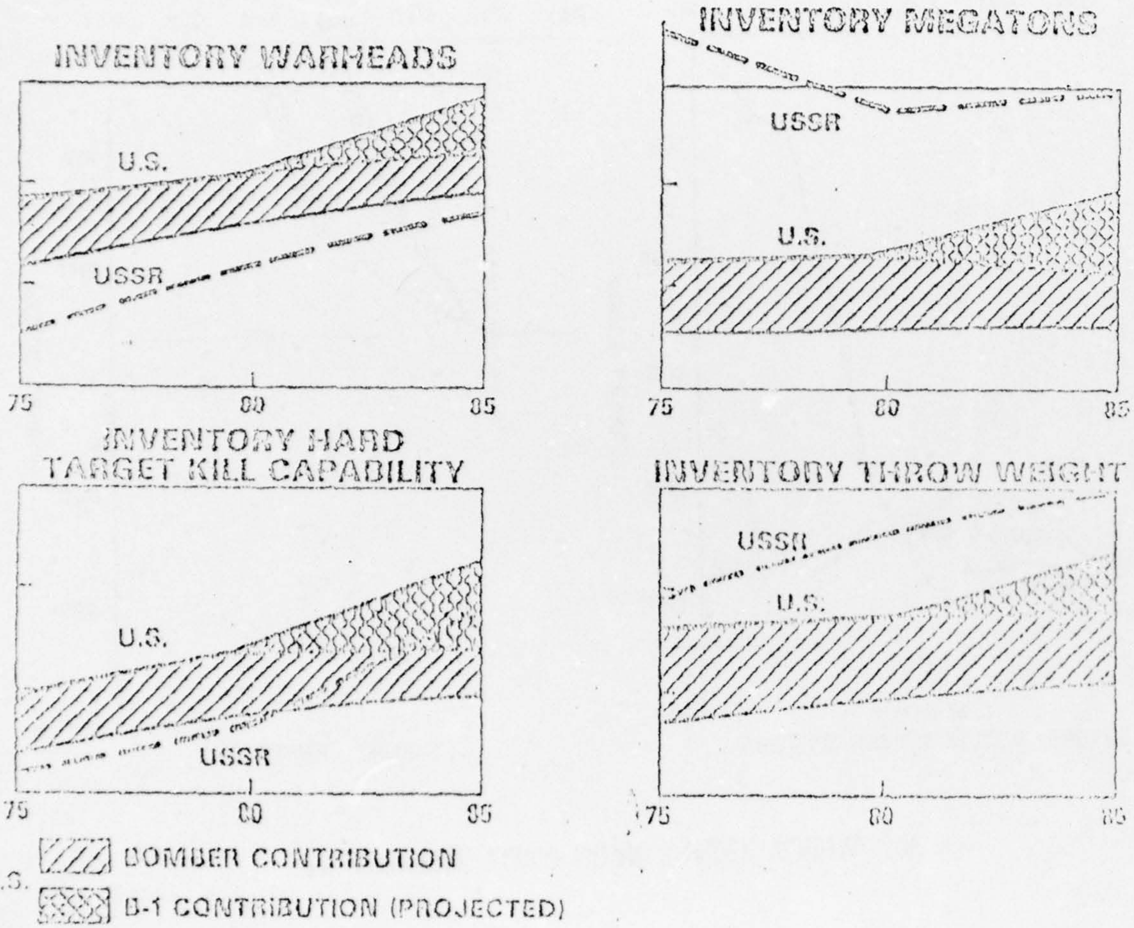
U.S. STRATEGIC FORCE LEVELS



ILLUSTRATIVE FORCE BALANCE UNDER VLADIVOSTOK

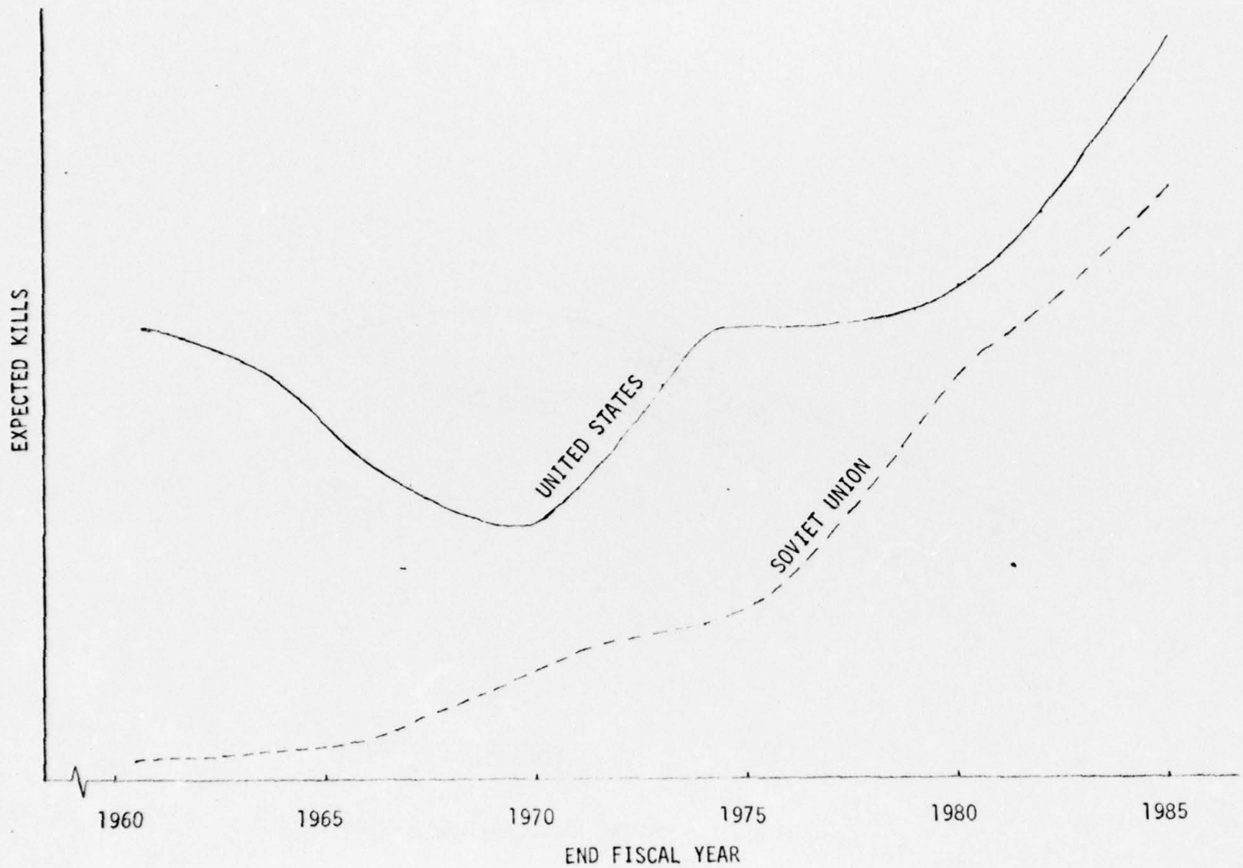


PERCEIVED BALANCE IN STRATEGIC FORCES



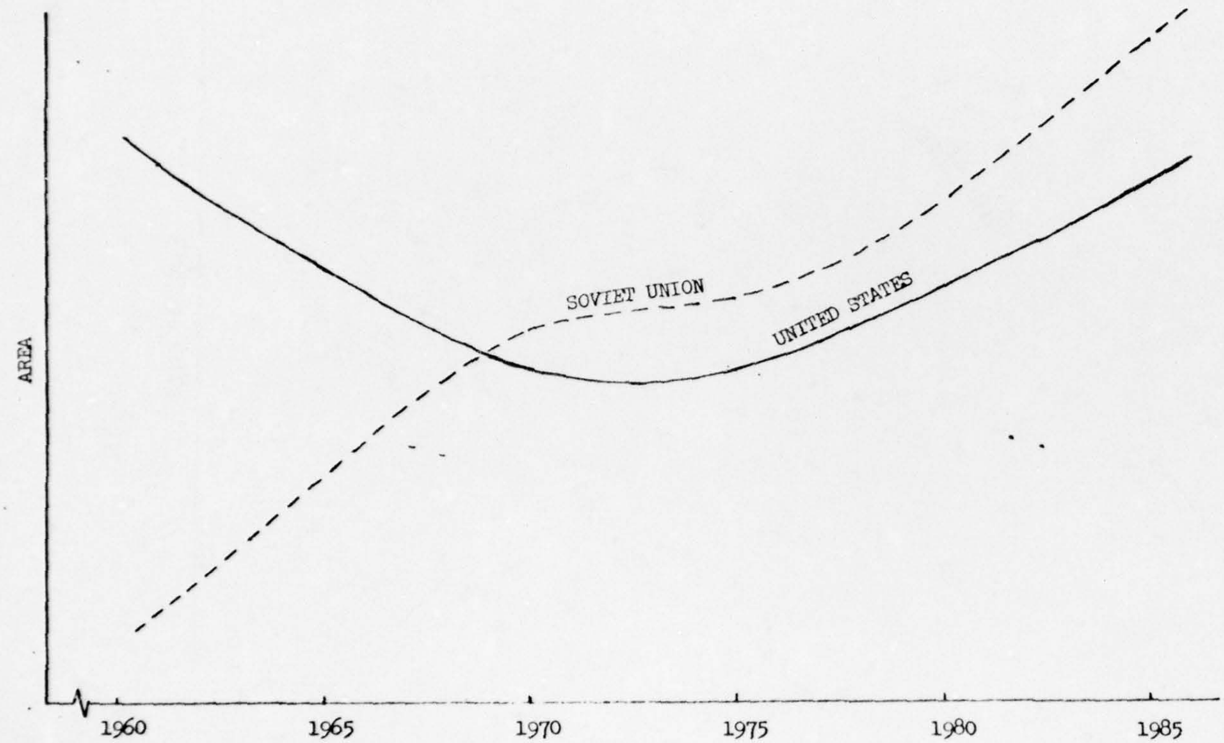
STATIC MEASURES OF THE STRATEGIC BALANCE

Soft Target Kill



STATIC MEASURES OF THE STRATEGIC BALANCE

Lethal Area (10 PSI)



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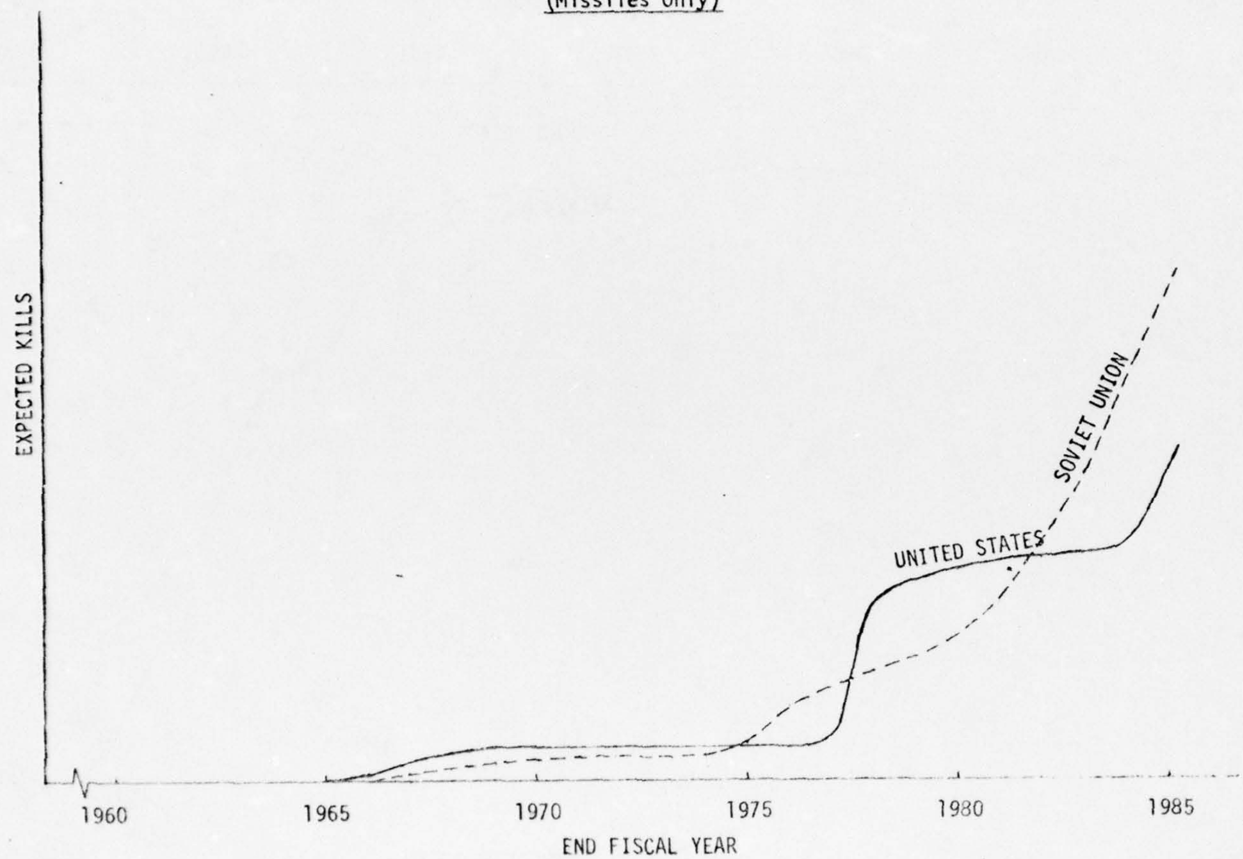
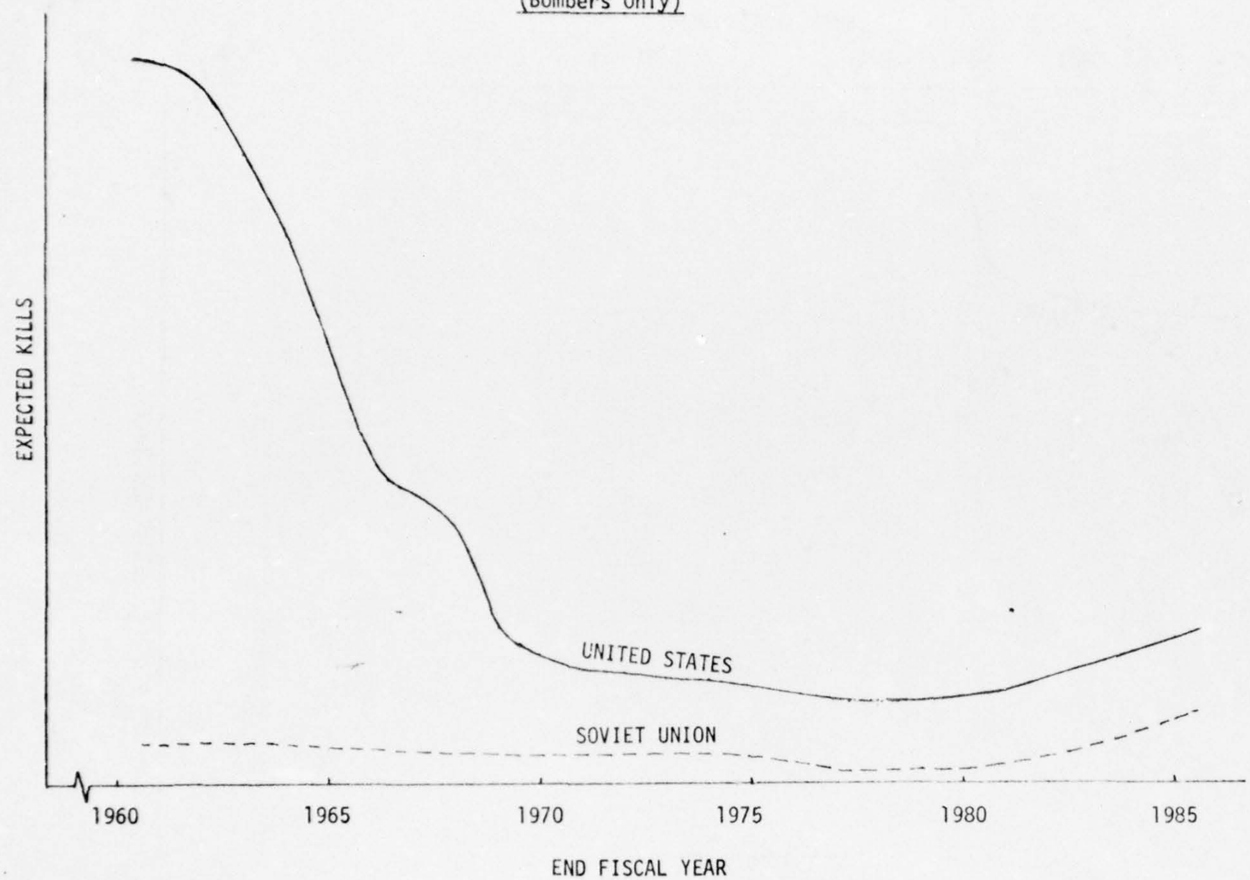
STATIC MEASURES OF THE STRATEGIC BALANCE

Time Urgent Hard Target Kill
(Missiles Only)



STATIC MEASURES OF THE STRATEGIC BALANCE

Non-Time Urgent Hard Target Kill
(Bombers Only)



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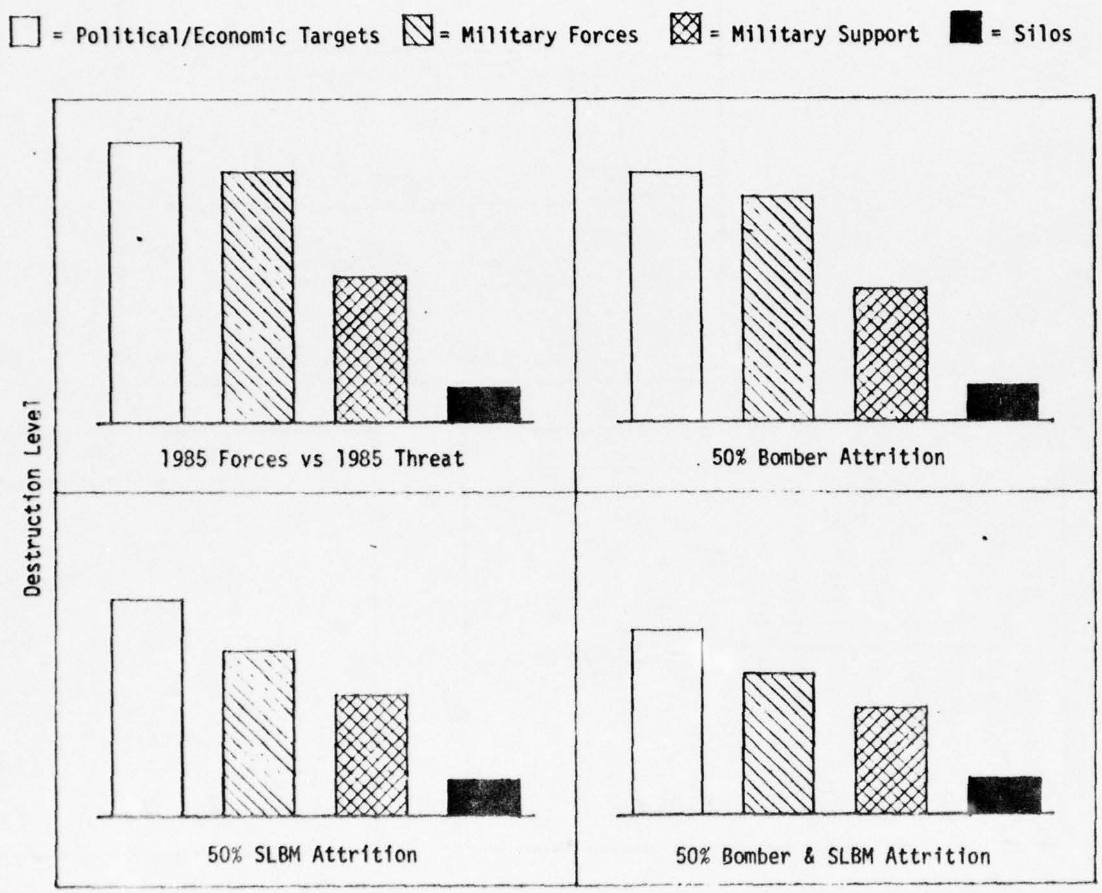
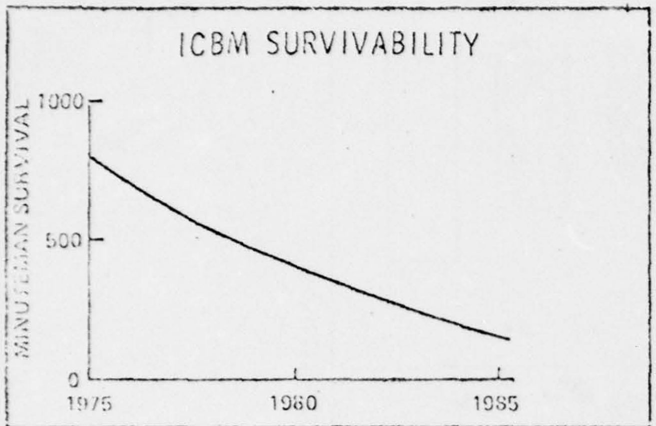
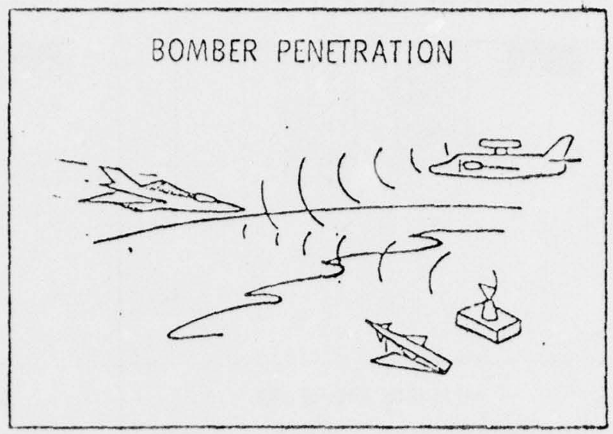
SENSITIVITY ANALYSIS

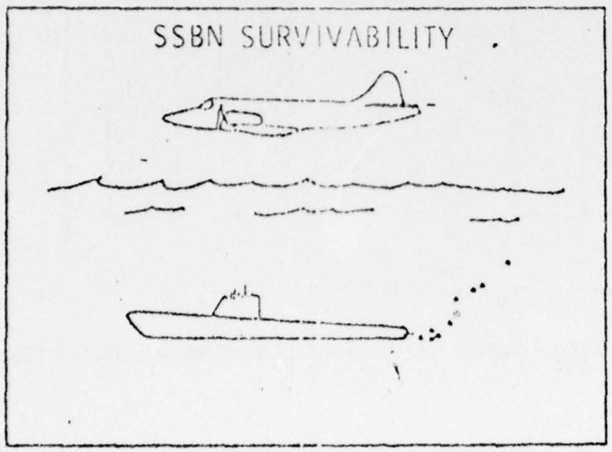
Day-to-day Alert Retaliatory Capability



MAJOR THREAT UNCERTAINTIES







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SUMMARY

- o MANY WAYS TO ILLUSTRATE STATIC BALANCE
- o STATIC BALANCE PRESENTS ONLY A PART OF THE TOTAL PICTURE
- o DYNAMIC ANALYSIS REQUIRED
- o TOTAL MILITARY POSTURE MUST BE CONSIDERED